SANTA CRUZ ISLAND PRIMARY RESTORATION PLAN

CHAPTER THREE
AFFECTED ENVIRONMENT

Introduction

This chapter focuses on portions of the environment that are directly related to conditions addressed in the alternatives. The description of the affected environment is not meant to be a complete description of the project area. Rather, it is intended to portray the significant conditions and trends of the resources that may be affected by the proposed project or its alternatives. Information in this chapter is based primarily on inventory and monitoring data from the Park's resource management staff, information provided by The Nature Conservancy, U.S. Fish and Wildlife draft recovery plan for 13 plant taxa of the northern channel islands, independent academic research studies, and studies conducted as part of this proposed action. Other sources are noted where applicable.

This chapter is organized into four sections, which when taken together provide the most complete description of the island resources, including the human element. The four major components of this chapter are:

- Physical Environment
- Terrestrial Environment
- Cultural Resources
- Human Uses and Values

For the most part, geologic and climatological conditions, processes, and disturbances cannot be altered by management activities. Watershed, soil, and atmospheric conditions and processes, also part of the physiographic setting, can be modified by certain management activities, and such impacts are outlined in Chapter Four, Environmental Consequences.

Physical Environment

Setting

Off the coast of southern California, eight ridges in the continental shelf rise above sea level, forming a series of islands. The four northern islands are located in the Santa Barbara Channel parallel to the coast south of Point Conception; the four southern islands are scattered offshore between Los Angeles and the Mexican border.

The Channel Islands vary greatly in size, distance from each other, and distance from the mainland, creating an immense natural laboratory of isolation and evolution. Because the islands have escaped much of the historical human impact on coastal California, they provide an ideal place for field scientists to perform work no longer possible on the mainland.

Of all the Channel Islands, the largest and most diverse is Santa Cruz. Totaling 60,784 acres, Santa Cruz Island is almost three times the size of Manhattan. One of the northern Channel Islands, it lies southwest of the City of Ventura, 19 miles across the Santa Barbara Channel from the nearest mainland point.

The National Park Service owns the eastern end of Santa Cruz Island, including the area known as the "isthmus". The Nature Conservancy owns the remainder of the island (Figure 1).

Like the state of California in miniature, SCI has two major mountain systems flanking a fault-dominated central valley. SCI's valley divides the island into two very different geologic terraines. To the north, a purple-brown ridge of young volcanic rocks rises to Mt. Diablo, then plunges abruptly into the Santa Barbara Channel. At 2,432 feet, Mt. Diablo is the highest point on all the Channel Islands. South of the Central Valley is a weathered ridge of reddish metamorphic rocks that reaches an elevation of 1,523 feet. At its seaward base, a submerged shelf extends several miles southward before falling off into the Santa Cruz Basin, which is more than a mile deep. Cutting through both ridge systems is a series of steep-sided canyons, many with freshwater springs and intermittent streams. Some of these creeks expire on gravel beaches at canyon mouths; others plunge from ocean cliffs directly into the sea. The island's main watershed has an interesting drainage pattern: Its primary stream flows southeast along the central valley, then turns abruptly northeast to drain through a steep gorge in the northern range to its mouth at Prisoners' Harbor.

The island's coastline includes a variety of exposures, from protected coves and sandy beaches to vertical cliff faces, hidden sea caves, and dissected marine terraces. Offshore, warm southern waters mingle with cold currents from the north, creating a major transition zone for marine life.

The diversity of the island's topography and microclimates gives rise to a wide array of habitats, from rocky intertidal to chaparral to pine forests. Its size and complexity make the island biologically similar to undisturbed areas on the adjacent mainland. But because of SCI's geographic isolation, its ecosystems exhibit subtle and not-so-subtle differences from their mainland counterparts, inviting comparative studies.

The island's biota includes many organisms endemic to the Channel Islands, some found only on Santa Cruz Island. Scientists believe most plants and animals reached the island by chance after swimming, flying, or floating on debris, especially during periods of low sea level.

Considering that it was colonized by overwater dispersal, Santa Cruz Island supports a remarkably rich biota. Some groups, however, are decidedly depauperate, and certain organisms, lacking the usual competitors or predators, have taken on different forms or have invaded niches unavailable to them on the mainland.

Aboriginal people, who traveled extensively between the mainland and the islands, may have introduced some organisms. SCI's abundant, well-preserved archaeological sites provide insight into past cultures and environmental conditions. The island's seclusion, ruggedness, and history of conscientious private stewardship have protected the island from many of the usual impacts of heavy exploitation following European contact.

Exotic plants and animals have affected the vegetation and soils of SCI. Efforts are underway by all stewards of the island to deal with non-native organisms. The most recent

successful effort was the removal of over 9000 sheep from the island ending in December 2000.

Climate

Precipitation and Temperature

The Channel Islands enjoy the Mediterranean climate typical of the central California coast. Rain pelts the islands off and on from November to March, but is scarce from late May to October, when a stable pacific high-pressure system settles off the coast. A shallow coastal marine layer helps lessen the impact of the common summer drought conditions on the islands.

Northwesterly winds blow throughout the year, picking up speed most afternoons and dropping off at night. These winds drive fog against the islands' northwestern slopes, which provide very different climatic conditions than the south-facing coastal slopes of the mainland. Santa Ana winds occasionally disrupt this pattern, particularly in the fall and early winter. These hot dry winds blow from the east when high-pressure systems are present in the interior mainland.

Drought

Drought is an important process that affects ecosystems. Drought is defined as an absence of usual precipitation (less than 75 percent of normal), for a long enough period that there is decreased soil moisture and stream flow, thereby affecting ecological processes and human activities. Typical of Mediterranean climates, the islands have their dry season during the summer months.

Geology

Much of the tumultuous geologic history of the Channel Islands can be read in the rocks of SCI (Gustafson, 1999). Cleaving the island in two is the Santa Cruz Island Fault, which juxtaposes 150 million-year-old metamorphic rocks with volcanics less than 20 million years old. Ongoing research suggests this fault has been very active recently, causing as much as 200-300 meters of movement in the last 30,000 years. This displacement can be seen in several areas where streambeds jog markedly as they cross the fault.

A pronounced but discontinuous central valley, formed by stream erosion along the fault zone, runs the length of the island from east to west separating two major ridge systems.

Other features of geologic interest on SCI include sheep-induced erosion, diverse soils, unusual drainage patterns, and Pleistocene fossils of dwarf mammoths and Douglas fir.

Air Quality

Though very little historic record exists with respect to air quality around the Channel Islands, it is probable that the combination of prevailing wind patterns, a low natural fire history, and small human populations allowed for generally good air quality. Since the population and development boom along coastal southern California, however, poor air quality is widespread, and smog often mars the visibility from and around the islands.

Channel Islands National Park is classified as a Class II area under the Federal Clean Air Act (42 USC 7401 et seq.). Class II areas are protected under the Clean Air Act, but have somewhat less stringent protection from air pollution damage than class I areas. The Act gives federal land managers the responsibility for protecting air quality and related values, including visibility, plants, animals, soils, water quality, cultural and historic structures and objects, and visitor health from adverse air pollution impacts.

Channel Islands NP Headquarters/Visitor Center and Anacapa Island are located in Ventura County, CA, and Santa Cruz, San

Miguel, Santa Rosa, and Santa Barbara Islands are located in Santa Barbara County, CA. Both counties are part of the South Central Coast Air Basin. The Ventura County Air Pollution Control District and the Santa Barbara County Air Pollution Control District are the governing authorities that have primary responsibility for controlling air pollution from stationary sources in Ventura County and Santa Barbara County, respectively. Table 4 summarizes the air quality designation of these counties.

Table 4. Ambient Air Quality Designations

Pollutants	Ventura County, CA		Santa Barbara County, CA	
	CA	National	CA	National
Ozone (one-hour)	N	N[1]	N	N[1]
Carbon monoxide	A	U/A	A	U/A
Nitrogen dioxide	A	A	A	A
Sulfur dioxide	A	A[2]	A	U
Particulate matter	N	U	N	U
Lead[3]	A		A	

A = Attainment N = Nonattainment T =Transitional U = Unclassified

[1] Although Ventura and Santa Barbara Counties are designated as nonattainment for the federal ozone standard, the Channel Islands are designated as unclassified/attainment

[2] Although Ventura County is designated as attainment for the federal SO_2 standard, the Channel Islands are designated as unclassified

[3] There are no areas in California that exceed the National standard for lead

Although there is no ozone monitoring station on Santa Cruz Island, neighboring Santa Rosa Island contains a continuous ozone monitoring station. This station is operated through a cooperative agreement between the NPS and the Santa Barbara County Air Pollution Control District. A summary of ozone emissions from this station is summarized in Table 5.

Standards for Prescribed Fire

The California Air Resources Board (ARB) is responsible for promulgating regulations pertaining to a variety of areas, including state ambient air quality standards and area designations, emissions from motor vehicles, fuels and consumer products, and airborne toxic control measures. Title 17 of the California Code of Regulations, titled Smoke Management Guidelines for Agricultural and Prescribed Burning, provides direction to air pollution control and air quality management districts (air districts) for the regulation and control of agricultural burning, including prescribed burning. The Guidelines are intended to provide for the continuation of prescribed burning as a resource management tool, while minimizing smoke impacts on the public. Local and regional authorities have the primary responsibility for control of air pollution from prescribed burning.

The Santa Barbara Air Pollution Control District requires that NPS prepare and submit a smoke management plan for the fennel burn. As a minimum the plan would include: 1) location and specific objectives of the burn project; 2) acreage or tonnage, type, and arrangement of vegetation to be burned; 3) directions and distances to nearby sensitive receptor areas; 4) fuel condition, combustion, and meteorological prescription elements developed for the project; 5) projected schedule and duration of project ignition, combustion and burndown; 6) specifications for monitoring and verifying critical project parameters and 7) specifications for disseminating project information.

Table 5. Santa Rosa Island 3-year average fourth highest daily max 8-hr ozone concentration based on data collected during the reported year and the two previous years.

Year	3-Year Avg 4th High Daily Max 8-hr Ozone (ppb)	3-Year Avg Data Complete	Data Complete % Met?	Annual 1st High Daily Max 8-hr Ozond (ppb)	Annual 2nd High Daily Max 8-hr Ozone (ppb)	Annual 3rd High Daily Max 8-hr Ozone (ppb)	Annual 4th High Daily Max 8-hr Ozone (ppb)	Annual 5th High Daily Max 8-hr Ozone (ppb)
2001 (a)	NA	NA	NA	NA	NA	NA	NA	NA
2000	66	87%	No	76	71	68	65	64
1999	67	93%	Yes	77	76	74	70	69
1998 (b)	*	*	*	*	*	*	*	*

a. 2001 data is not yet available

b. Data Completeness was not met. Summary data indicates that the highest ozone daily 1-hr average maximum concentration was 82 ppb recorded on 10/6/98. There were no episodes of 8-hr avg ozone concentrations greater than 84 ppb.

Soils/Water Quality

This section will describe the current condition and trend of soil resources and water quality on Santa Cruz Island. However, because there has not been a soil survey or permanent water quality stations established on Santa Cruz Island, information on these two subjects is not well documented. In cooperation with the Natural Resource Conservation Service, Channel Islands National Park has begun a soil survey for all Park islands, including Santa Cruz Island. This survey is expected to be complete within three years.

Geology and its Relation to Soil Erosion

Disturbance factors such as heavy past livestock grazing, pig rooting, and extensive vegetation type changes, when acting on steep landform features and erosion prone sedimentary geologic types, have caused localized downward trends in soil resources.

Gully and sheet erosion is still actively occurring throughout the island, especially within the sedimentary Monterey formations found on the isthmus and east end of the island. The El Niño winter storm events of 1997-98 caused hundreds of small and large landslides throughout the island. This was particularly noticeable in the Scorpion watershed, one of the most disturbed watersheds on the island, which is extremely vulnerable to erosion due to past heavy sheep grazing, pig rooting, steep landforms, and geologic type (half of the watershed is in the Monterey formation).

The volcanic geologic types found on the northwestern part of the island and on the higher elevations of the island's east-end are less prone to erosion. However, because this geologic type supports many of the tree-dominated community types, they have been a natural resting area for feral sheep, as well as preferred habitat for pigs foraging for acorns. Even though they may be less prone to erosion, the feral animal activity has impacted them dramatically in localized areas.

Watershed Features

Watersheds on Santa Cruz Island vary greatly in size. The largest watershed is the Central Valley, which runs east/west and drains out to the north shore at the base of the isthmus. Landforms within the watersheds vary, however almost all of them have steep slopes with highly dissected drainages.

Typical Santa Cruz Island watersheds are characterized by steep, highly dissected subdrainages. Most of the steep slopes show many mass slope failures that result in high erosion and sedimentation in the valleys. Most of the major watersheds have a mix of vegetation community types, with coastal sage scrub on south facing slopes, chaparral on north facing slopes on volcanic substrates, and woodland communities in the higher elevations with steeper slopes. Incised gullies are commonplace throughout the drainages, a situation that was exacerbated by the overgrazing of sheep. Slope failures of all sizes are also very evident throughout the watershed, although fewer slope failures are evident in watersheds that are in the volcanic geologic types.

Valley-bottom Characteristics

The highly dissected drainages typically have V-shaped valley-bottoms. These drainages are highly efficient at delivering sediment. These valley-bottom types, when coupled with low vegetation cover are capable of causing "flash flood" events. This situation contributed to the December, 1997 Scorpion Flood. Near the ocean confluence, the larger drainages are typically low gradient and U-shaped and may contain estuary habitat.

Streamflow and Water Quality

Most drainages have only intermittent above ground stream flow. However, the larger watersheds have perennial flow in normal precipitation years. Drought conditions play a major role in extent of above surface streamflow. Even the largest watershed on the island (Central Valley) has intermittent flow, where stream flow alternates above and below ground throughout its length. Junak et. al. (1995) notes that there are many freshwater seeps and springs throughout the island. One of the largest springs on the island is located in Aguaje Canyon near Yellowbanks Anchorage. Minimal documentation exists as to water chemistry (nutrients or animal waste) monitoring within the streams of Santa Cruz Island, so presence of microbes or nutrients is unknown. Given the island's ranching history, and the resultant declining vegetation conditions, sedimentation above natural sediment rates is a concern for water quality.

Terrestrial Environment

Introduction

This section provides a description of the terrestrial component of Santa Cruz Island that is directly related to conditions addressed in the alternatives. As such, it is not a complete description of the entire terrestrial environment; rather it is a description of the significant conditions and trends of resources that may be affected by the proposed project or its alternatives. Listed below are the three terrestrial components that will be described in this section:

- Wildlife
- Native Vegetation, including Threatened and Endangered plant species
- Fennel and other weeds

Wildlife

Introduction

Santa Cruz harbors fewer species than comparable mainland areas, because only a subset of the mainland species pool successfully colonized the island. This is typical of island faunas. On the other hand, evolution of island forms in relative isolation from their mainland ancestors has resulted in a high degree of endemism in the fauna of Santa Cruz Island, and

for the fauna of islands as a whole. Endemic taxa (species or subspecies) are those that are restricted to a particular geographic locale.

Non-avian Vertebrates

Eight species of reptiles and amphibians have been recorded for Santa Cruz Island (Table 4), of which 3 are endemic to the island or archipelago. One reptile, the Santa Cruz gopher snake, occurs only on Santa Cruz and Santa Rosa Islands. Fifteen species of mammals, including 11species of bats, have been recorded on Santa Cruz (Table 6). Three of the 4 non-bat mammals occur only on Santa Cruz, and the other (the island spotted skunk) occurs only on Santa Cruz and Santa Rosa Islands.

Because of their unique taxonomic status and questionable population status, several species are treated in greater detail.

Island Spotted Skunk

Island spotted skunks (*Spilogale gracillis amphiala*) occur only on Santa Cruz and Santa Rosa Islands, having possibly been extirpated from San Miguel Island (Walker 1980). Very little is known about the ecology of the Channel Islands spotted skunk. Difficulty in trapping skunks has plagued the few investigations that have been attempted. Crooks (1994) studied the comparative ecology of the spotted skunk on

Table 6. Santa Cruz Island Fauna

Common Name	Scientific Name [1]	Legal Status[2]	Endemic Status
AMPHIBIANS			
Blackbelly slender salamander	*Batrachoseps nigriventris*		
Channel Islands slender salamander	*B. pacificus pacificus*	FSC	Channel Islands
Pacific tree frog	*Pseudacris regilla*		
REPTILES			
Southern alligator lizard	*Elgaria multicarinata*		
Island fence lizard	*Sceloporus occidentalis beckii*		Channel Islands
Side-blotched lizard	*Uta stansburnia*		
Santa Cruz gopher snake	*Pituophis catenifer pumilus*	FSC, CSC	SCI, SRI
Western yellowbelly racer	*Coluber constrictor mormon*		
MAMMALS			
California myotis	*Myotis californicus caurinus*		
Big-eared myotis	*M. evotis*	FSC	
Fringed myotis	*M. thysanodes*	FSC	
Townsend's western big-eared bat	*Corynorhinus townsendii townsendii*	FSC, CSC	
Big brown bat	*Eptesicus fuscus*		
Pallid bat	*Antrozous pallidus pacificus*	CSC	
Silver-haired bat	*Lasionycteris noctivagans*		
Hoary bat	*Lasiurus cinereus*		
Red bat	*L.borealis*		
Mexican free-tailed bat	*Tadarida brasiliensis*		
Western mastiff bat	*Eumops perotis californicus*	FSC, CSC	
Santa Cruz Island deer mouse	*Peromyscus maniculatus santacruzae*		Island
Santa Cruz Island harvest mouse	*Reithrodontomys megalotis santacruzae*	FSC	Island
Santa Cruz Island fox	*Urocyon littoralis santacruzae*	ST, FPE	Island
Island spotted skunk	*Spilogale gracilis amphiala*	FSC, CSC	SCI, SRI

[1]Nomenclature for reptiles and amphibians is from Collins (1990).
[2]FSC = Federal Species of Special Concern; CSC = California Species of Special Concern; ST = State-listed as Threatened. Data on legal status is from California Department of Fish and Game (1998).

Santa Cruz Island in relation to the island fox. He found that skunks were rare and difficult to capture; that they were habitat specialists, preferring ravines, and to a lesser extent, chaparral-grasslands; and that they were entirely carnivorous and nocturnal. Crooks concluded that the low population size and relatively narrow geographic range of the skunk made the species vulnerable to extinction.

The skunk is listed as a "Species of Special Concern" by the State of California and the National Park Service. According to von Bloeker (1967), spotted skunks were once very common on Santa Cruz and Santa Rosa Islands, but by 1967 they were rarely found on either island, at least near human dwellings. The apparent rarity of spotted skunks may reflect normal population fluctuations, or it may reflect a real decline in numbers (Williams, 1986).

Recent observations from Santa Cruz Island and Santa Rosa Island indicate that island spotted skunks have increased in numbers, at the same time that island foxes have decreased (G. Roemer, Institute for Wildlife Studies, unpublished data; K. Crooks, University of California, Santa Cruz, pers. comm., T.Coonan, NPS, unpublished data).

Landbirds

Fifty-one species of landbirds are known to breed on Santa Cruz Island (Diamond and Jones 1980). Eight of those taxa are subspecies endemic to two or more of the northern Channel Islands, while one, the island scrub-jay, is a species endemic to Santa Cruz Island. Three of the endemics (horned lark, rufous-crowned sparrow, and loggerhead shrike) exist at low population levels (H. Walter, University of California, Los Angeles, unpublished data).

Several pairs of peregrine falcons, a species formerly listed as endangered, breed annually on the island. Bald eagles are currently listed as threatened under the Endangered Species Act, but have been proposed for de-listing. They formerly bred on Santa Cruz Island, and on all other Channel Islands, but were extirpated in the mid-20th century due to persecution and effects of DDT and other related compounds (Kiff 1980).

Invertebrates

The invertebrate fauna of Santa Cruz Island is much less well known than the vertebrate fauna, due to greater traditional interest in the latter, and the far greater number of taxa in the former. Powell (1994) estimated that lepidopteran fauna of Santa Cruz Island was about 70-75% known. In contrast he estimated that at that time, San Miguel and Santa Rosa lepidopteran fauna was only 50% known. About 750 species of lepidopterans are known from the Channel Islands, about 550 of them from Santa Cruz Island. Fourteen lepidopteran species known from Santa Cruz are endemic to one or more of the Channel Islands (Powell 1994). The butterfly and moth fauna of Santa Cruz Island is depauperate for the same reasons that island vertebrate species are typically depauperate: absence at time of island genesis, subsequent extinction, and failure to colonize (Powell and Wagner 1993).

The native bee fauna of Santa Cruz Island is well known, due to research on the effects of non-native European honeybees (*Apis mellifera*) on native bees (Thorp et al. 1994). The bee fauna of Santa Cruz is more diverse than that on other Channel Islands, due to the island's size, elevations, topographical diversity, and habitat variability. European honey bees have been all but eradicated from the island (Wenner et al., in press).

Threatened or Endangered Animal Species

Two listed animal species, the Western snowy plover (*Charadrius alexandrinus nivosus*) and the California brown pelican (*Pelecanus occidentalis californicus*), occur on Santa Cruz Island. One listed species, the bald eagle (*Haliaeetus leucocephalus*), will be

experimentally reintroduced to Santa Cruz Island in 2002.

The island fox (*Urocyon littoralis*) occurs on Santa Cruz Island. In December, 2001, the U.S. Fish and Wildlife Service proposed for listing as endangered four subspecies of the island fox, including the Santa Cruz Island subspecies (*U. l. santacruzae*). A final rule listing those subspecies as endangered could become effective in December 2002.

Island Foxes

The island fox, a diminutive relative of the gray fox (*U. cinereoargenteus*), is endemic to the California Channel Islands. It is distributed as six island populations, each varying in size from fewer than a hundred, to a few thousand individuals. The fox exists as a different subspecies on each of the six islands, a distinction upheld by morphological and genetic work (Wayne et al. 1991, Collins 1993). The subspecies on Santa Cruz Island is *U. l. santacruzae*. Due in part to its limited distribution and small numbers, it was been listed as a threatened species in California (California Department of Fish and Game 1987). A substantial amount is known about this species' population ecology and evolutionary history due to recent work on island fox genetic variability (Gilbert et al. 1990), evolution (Wayne et al. 1991), disease incidence (Garcelon et al. 1992), and population status and conservation (Roemer et al. 1994, Roemer 1999). Channel Islands National Park encompasses five of the eight California Channel Islands and includes three islands that harbor different island fox subspecies.

Island foxes occur in virtually every habitat on the Channel Islands and feed on a wide variety of prey (Moore and Collins 1995). They occur in valley and foothill grasslands, southern coastal dune, coastal bluff, coastal sage scrub, maritime cactus scrub, island chaparral, southern coastal oak woodland, southern riparian woodland, Bishop and Torrey pine forests, and coastal marsh habitat types. Island fox home range size varies by habitat type, season, and sex of the animal (Fausett 1982, Laughrin 1977, Crooks and Van Vuren 1995, Thompson et al. 1998, Roemer 1999). The island fox diet includes a wide variety of plant and animal materials (Laughrin 1973, 1977, Crooks and VanVuren 1995; Moore and Collins 1995). Island foxes forage opportunistically on any food items encountered within their home range. Selection of food items is determined largely by availability, which varies by habitat and island, as well as seasonally and annually. Principal foods eaten include mice, ground nesting birds, arthropods, and fruits.

Island fox populations were annually monitored on San Miguel Island from 1993 to 1999, and on Santa Cruz Island from 1993 to present. The island fox population on San Miguel declined beginning in 1994 (Coonan et al. 1998) with the adult population falling from 450 in 1994 to 15 in 1999. The Santa Cruz population declined from approximately 2,000 adults in 1994 to perhaps less than 135 in 2000 (Roemer 1999), and the current population is probably 50-60 adults (Dennis et al. 2001; D. Garcelon, Institute for Wildlife Studies, unpubl. data). Survey data from Santa Rosa Island (G. Roemer, Institute for Wildlife Studies, unpublished data) indicate that island foxes experienced a similar catastrophic decline on that island as well. Foxes on Santa Rosa may have numbered more than 1,500 in 1994 (Roemer et al. 1995) but have since declined to 31 animals, all in captivity (Coonan and Rutz 2001).

Using population viability analysis, Roemer (1999) estimated time to extinction at five years for island foxes on San Miguel and 12 years for island foxes on Santa Cruz.

Predation by non-native golden eagles (*Aquila chrysaetos*) is the primary mortality factor now acting upon island foxes on the northern Channel Islands, and is likely responsible for the massive decline of the past five years (Roemer 1999, Roemer et al. 2001). Golden eagle predation was identified as cause of death for 19 of 21 island fox carcasses found

on Santa Cruz Island from 1993 to 1995. On San Miguel Island in 1998-1999, four of eight radiocollared island foxes were killed by golden eagles in a four-month period, and another two died of unknown causes. In 2001, nine of 27 radiocollared island foxes died from golden eagle predation (Dennis et al. 2001; D. Garcelon, Institute for Wildlife Studies, unpubl. data). This level of golden eagle predation is unnatural. Until recently, golden eagles have never bred on the Channel Islands and their recent appearance is due to a prey base, feral pigs (*Sus scrofa*), that was not present prehistorically.

In a recent study to determine distribution and abundance of island foxes on Santa Cruz Island, most foxes were found in the Central Valley and in the Isthmus area (Dennis et al. 2001; D. Garcelon, Institute for Wildlife Studies, unpubl. data). Of the 82 individual foxes trapped during the study, 22 were trapped in the thick fennel stands on the Isthmus, which may provide foxes with more cover from golden eagles than do other habitat types on Santa Cruz Island. Crooks and Van Vuren (1995) found foxes in the isthmus of Santa Cruz Island to prefer fennel grasslands over ravines and patches of scrub oak.

The absence of bald eagles (*Haliaeetus leucocephalus*), which bred historically on the islands and whose presence may have kept golden eagles away, is another contributing factor driving increased golden eagle predation. Moreover, on much of the northern Channel Islands, historic sheep grazing changed the predominant vegetation from shrub to non-native grasslands, which offer much less cover from aerial predators.

Concerned about the potential loss of three subspecies of island foxes from its lands, the Park convened an island fox recovery team in April 1999 to consider the available information and develop strategies to recover island fox populations to viable levels. The team concluded that:

- predation by golden eagles is the primary mortality factor now acting on the population
- disease or parasites may be compounding the effects of predation
- natural recruitment is low
- the most effective conservation measure that could be taken right now is to increase survival of pups, juveniles and adults by reducing or eliminating golden eagle predation

The team recommended that the Park implement the following emergency measures to safeguard island foxes and to recover fox populations on the northern Channel Islands:

- Relocate golden eagles from the northern Channel Islands
- Establish fox sanctuary/captive breeding programs on Santa Rosa and San Miguel Islands
- Eradicate feral pigs
- Reintroduce bald eagles

Upon receiving these recommendations, the Park began taking emergency recovery actions in 1999. In summer 1999 the Park constructed pens on San Miguel and began capture of wild island foxes. By January 2000, 14 island foxes had been captured and placed in the pens. Only four of those were males, and so eight San Miguel Island foxes were paired for breeding purposes. The captive population increased from 14 to 21 animals after two years of reproduction. There is only one fox left in the wild on San Miguel Island. A captive breeding program was initiated for Santa Rosa Island in 2000. The captive population on Santa Rosa increased from 14 to 32 foxes after two years of captive breeding, and there are none left in the wild on that island.

The Park established a cooperative agreement with the Santa Cruz Predatory Bird Research Group (SCPBRG) in 1999 for the purpose of relocating golden eagles from the northern Channel Islands. Personnel from the

SCPBRG began eagle surveys on Santa Cruz Island, the island with the most recent sightings, in late summer 1999. During that time period a helicopter crew working on East Santa Cruz Island noted a large stick nest in a canyon. Biologists from SCPBRG rappelled into the nest and confirmed that it was an active golden eagle nest, the first confirmed nesting by golden eagles on the northern Channel Islands. Among the prey remains found in the nest were two adult island foxes, piglets, and ravens. To date 19 golden eagles have been removed from Santa Cruz Island with NPS and TNC support. Captured birds were released in northeastern California, and satellite telemetry indicates none have attempted to return to the islands. Three golden eagles remained on the island as of January 2002. However, other golden eagles may disperse from the mainland to the islands, and eagle monitoring and removal may be necessary until feral pigs are removed from the island, or bald eagles re-established.

The current status of eagles and foxes on Santa Cruz Island indicates that captive breeding is warranted for that island fox population. To date ten radiocollared island foxes died from golden eagle predation, and recent monitoring suggests there are only about 50-60 adult island foxes on the island. This population is too small to persist over time. Therefore in 2002 NPS and TNC will work to establish captive breeding for island foxes on Santa Cruz. .

In March 2001, the Park released to the public a draft recovery plan for island foxes on the northern Channel Islands (Coonan 2001). The recovery plan is in the format of U.S. Fish and Wildlife Service recovery plans, stating the threats to the species, delineating goals, objectives and recovery criteria, and presenting a schedule and cost estimates for recovery actions. Appropriate recovery goals for each of the three island fox subspecies in the northern Channel Islands were set with the assistance of demographic modeling. Population viability analysis was used to identify target population levels that would minimize the chance of extinction. Modeling was then used to set an augmentation (captive breeding and release) schedule that would achieve those targeted goals in a reasonable timeframe.

The island recovery plan calls for a continuation of the emergency actions of island fox captive breeding and golden eagle removal, as well as the separately funded actions of feral pig removal and reintroduction of bald eagles to the northern Channel Islands. Full recovery of the San Miguel subspecies may take as long as a decade, although recovery on Santa Rosa and Santa Cruz may occur sooner. The plan was developed with input from U.S. Fish and Wildlife Service, and is likely to be adopted as part of a FWS recovery plan for the species, should the species be listed.

Bald Eagles

Bald eagles are currently listed as threatened under the Endangered Species Act, but have been proposed for de-listing. They formerly bred on Santa Cruz Island, and on all other Channel Islands, but were extirpated in the mid-20th century due to persecution and effects of DDT and other related compounds (Kiff 1980). Santa Cruz Island regularly supported at least five pairs of bald eagles, which nested in niches and potholes on the sea cliffs. Known nesting areas included Pelican Bay, San Pedro Point, Blue Banks, Valley Anchorage, Chinese Harbor, Potato Harbor, and Middle Grounds. Nearby Anacapa Island had as many as three nesting pairs in some years. Kiff estimates that the northern Channel Islands supported at least 10 nests, and probably more, at any one time.

The NPS is working with other agencies to restore bald eagles to the northern Channel Islands. In 2002, a consortium of agencies will implement a feasibility study for reintroduction of bald eagles, funded by the Montrose Chemical Company contaminant case settlement. Up to 12 bald eagle chicks will be hacked back on Santa Cruz Island annually for three to five years. Released birds and their prey items will be monitored to determine whether a breeding population can be established. The

primary factor limiting reestablishment may be levels of DDE in the environment. Since bald eagles do not mature and breed until four to five years of age, it may be some time before a breeding population is established.

Brown Pelicans

The California subspecies of the brown pelican was classified as endangered under the Federal Endangered Species Act in 1970, and was designated as endangered by the State of California in 1971. On the west coast of North America, pelican breeding colonies are located on West Anacapa Island, on Santa Barbara Island and on islands off the coast of Baja California. Pelicans also breed sporadically on Scorpion Rock off Santa Cruz Island. These colonies almost disappeared in the 1970's, due to egg-shell thinning caused by organochlorine pesticides in the environment (Carter et al. 1992). In 1971, only one chick successfully fledged.

The pelican breeding colonies have subsequently recovered. The number of birds in the breeding colony at West Anacapa Island has steadily increased to between 4,000 and 6,000 annual nesting attempts. This is in sharp contrast to the early 1970's in which there were only about 100 annual nesting attempts. On Santa Barbara Island, the once-ephemeral colony produces 400-700 nests every year. Pelican populations are now primarily affected by availability of their primary prey, northern anchovies (*Engraulis mordax*) (Carter et al. 1992).

Snowy Plovers

The Pacific coast population of the western snowy plover is federally listed as threatened. Western snowy plovers breed from Washington to Baja California, and winter in coastal areas from southern Washington to Central America. Western Snowy plovers breed primarily above the mean high tide line on coastal beaches, dunes, estuaries and lagoons. In southern California, snowy plovers are primarily found on San Miguel, Santa Rosa, and San Nicolas Islands, as well as in San Diego County and on Vandenburg Air Force Base in Santa Barbara County (Baird 1993). Counts of snowy plovers at Channel Islands National Park have declined since 1991. This decline in the park breeding population occurred concurrently with a decline in the breeding population in southern California.

Non-Native Pigs

Feral or domestic pigs (*Sus scrofa*) are an ungulate species not native to North America. Domestic pigs were brought to California by Spanish settlers in 1769 (Barrett 1999) and were introduced to Santa Cruz Island in 1852 (Schuyler 1988). The term "feral pig" refers to a wild pig that comes from domestic genetic stock, such as domestic livestock that escape to survive in the wild, as well as their progeny. By 1857 pigs had escaped and become feral on Santa Cruz Island. Wild pigs now occur in 52 of 58 California counties and are most abundant in forests, oak woodlands and chaparral.

Feral pigs are generalist omnivores with a diet that changes seasonally according to abundance of foods. Mast foods, such as acorns and berries, are important food items in the fall. Winter diets typically comprise roots, bulbs and invertebrates that pigs find by rooting in seasonally moistened soil. As soil dries during spring and summer, pig diets shift to green plants.

Feral pigs have high reproductive potential, and are considered the most prolific ungulate in the U.S. Sows can breed at six or seven months of age, and can produce up to two litters per year with as many as 10 piglets in each litter. Pig populations can more than double annually if not limited by food or water availability. Pig populations respond to changes in food availability and weather. Drought years can cause significant declines in population numbers due to starvation and reduced reproduction, whereas heavy mast crops following winters of high precipitation can allow pig populations to

increase significantly (Baber and Coblentz 1987, Sterner 1990). Pigs generally require access to permanent water, and abundant cover.

Feral Pigs on Santa Cruz Island

Most information about pig distribution and abundance on Santa Cruz Island comes from studies initiated in the 1980's. Feral pigs are found in all locations and habitat types on Santa Cruz Island (Schuyler 1988). As in other areas, they favor oak woodland throughout the year, but especially during the fall when the acorn crop is available. Pig utilization of chaparral and grassland habitat types increases during the winter and spring when grasses and forbs are emerging. Coastal areas are the least utilized, year-round. Ridge tops and higher slopes are utilized primarily during the wetter, cooler months. During the dry months pigs are typically found in canyon bottoms or on middle or lower slopes.

Reasonable pig population estimates for Santa Cruz Island were not available until the 1980's, although it is generally accepted that the removal of feral sheep from the island increased both vegetative cover and the carrying capacity for feral pigs (Baber 1982, Sterner 1990). Annual estimates of the island's pig population have ranged from 1,500 to over 4,000.

As an example of the large population swings that Santa Cruz Island pigs endure, a study by Sterner (1990) estimated the island population at 1261 in 1987, based upon island wide aerial and ground censuses. Because the censuses occurred after drought and hunting-induced mortality, the actual spring-summer pig population was thought to be higher than this. The pig population apparently doubled from 1987 to 1988, due to an increase in mast production, which included scrub oak (*Quercus dumosa*), island manzanita (*Arctostaphylos insularis*) and Catalina cherry (*Prunus ilicifolia lyonii*) (Sterner 1990). An aerial census in 1988 yielded an island pig population estimate of 3,165 ± 1,157. Pig densities were estimated at 15 – 24 pigs per km^2. Average litter size increased from 1.1 piglets per sow in 1987 to 3.2 in 1988.

Santa Cruz Island pig densities were found to be higher than densities reported from mainland sites in California (Sterner 1990). One reason for this may be lack of predators on the island; another is the smaller size of Santa Cruz Island pigs. Sterner (1990) reported that adult pigs on Santa Cruz Island weighed about half as much as mainland pigs.

Sterner (1990) also conducted a radiotelemetry study of feral pigs in the Willows pasture of Santa Cruz Island to determine home ranges and habitat utilization. He found pigs to prefer drainage bottoms, which pigs used as travel corridors, to ridge tops. Pigs selected areas close to cover and water sources. The Willows pasture was sufficiently heterogeneous that pigs did not prefer one habitat type over another.

All pigs were removed from a 4,500 ha exclosure in the Willows Pasture on Santa Cruz Island from 1989-1990, to evaluate the feasibility of eradication (Sterner and Barrett 1991). Pigs later breached the fence and recolonized the area.

Diseases of Feral Pigs

Wild and feral pigs can harbor various diseases, including pseudorabies, hog cholera, brucellosis, vesicular exanthema of swine (also known as San Miguel sea lion virus), trichinosis, and leptospirosis. Most of these diseases have been eradicated, or are highly limited in extent, on the California mainland through extensive inoculation programs. Recent sampling of the population indicates very low incidences of disease, if any, to occur. However, disease sampling can only provide guidance for trends, not comprehensive prevalence for disease within a population. Clearly, the potential for disease within the wild population of pigs is still quite large, especially within the context of high incidences of disease in the past.

Hog cholera is the most destructive and costly swine disease ever to occur in the U.S., but was eradicated by 1978. Hog cholera was introduced into both Santa Cruz and Santa Rosa Island pig populations earlier in the century in an attempt at eradication, but serologic testing of blood from island pigs in 1987 revealed no antibodies to hog cholera in that sample (APHIS 1988).

Pseudorabies virus is a herpes virus that causes pseudorabies infection (also known as Aujesky's disease, mad itch, and infectious bulbar paralysis). Most mammalian species are susceptible to infection, but pigs, which are the only reservoir for the virus, are most susceptible (Vandevelde 1990). The virus does apparently not affect humans. Transmission among pigs is direct, and can be venereal, since the boar sheds the virus in his semen. Transmission among pigs is also density dependent, with more transmission and higher prevalence of the disease at higher pig densities (Timm et al. 1994). Consuming contaminated raw pork can infect other mammals, particularly fur-bearing mammals, dogs, and cats. Pseudorabies is nearly always fatal in dogs. Pseudorabies can become enzootic in some pig populations, with few adverse effects at the population level. Alternatively, pseudorabies can cause up to 100% mortality in suckling pigs (Gustafson 1986, as cited in Timm et al. 1994). Mortality is much less in adult pigs, but effects include anorexia, weight loss and reproductive failure.

Antibodies to pseudorabies virus were detected in pig blood samples from both Santa Cruz and Santa Rosa Islands in the 1980's, prompting the Secretary's Advisory Committee on Foreign Animals and Poultry Diseases to recommend against live removal of pigs from those islands to the mainland (Glosser 1988). On Santa Catalina Island, 25% of 366 pigs tested positive for antibodies to pseudorabies (Timm et al. 1994), with adults having higher seroprevalence than juveniles. Effects of the disease on individuals and the population were not apparent. Seroprevalence (the presence of antibodies) indicates exposure to a disease, but does not necessarily equate to infections.

Brucellosis is a disease caused by bacteria of the genus *Brucella* that can cause reproductive failure in the form of abortions and reproductive organ infections (Davis 1999). The disease is zoonotic, or capable of being transmitted to humans, in whom it can mimic severe flu and may lead to crippling arthritis or meningitis. Animals and humans are exposed to the *Brucella* bacterium by handling or contact with infected placentas, amniotic fluids, vaginal discharges, milk, semen, reproductive tissues, and exudates from infected animals usually just prior to and after an abortion. *Brucella suis* specifically affects pig populations. Other species include *B. canis*, which causes canine brucellosis, and *B. abortus*, which affects large ungulates such as bison and elk. It is not known whether feral pigs on Santa Cruz are infected with brucellosis. Timm et al. (1994) found no antibodies to brucellosis in Santa Catalina Island pig blood samples. In a survey of feral swine in California, 3.8% of 611 pigs were seropositive for brucellosis (Drew et al. 1992), but 90% of those positive animals were from only two counties. Brucellosis is thus locally influential in several pig populations in California.

San Miguel sea lion virus is a calicivirus which, in pigs, results in lesions identical to those produced by vesicular exanthema of swine disease. Antibodies for San Miguel Sea lion virus have been found in serum from both feral pigs and island foxes on Santa Cruz Island (Prato et al. 1974, 1977), and in pigs on Santa Catalina Island (Timm et al. 1994). Vesicular exanthema of swine and San Miguel sea lion virus in foxes may have a marine origin on Santa Cruz Island (Prato et al. 1974, 1977), since pigs and foxes forage at pinniped haul-out sites.

Trichinosis is a zoonotic disease caused by the parasite *Trichinella spiralis* and passed to humans by the consumption of infected, undercooked meat. It is very rare in wild pigs in California, with only a 1% occurrence (Jessup and Swift 1993). It is not known if Santa Cruz

Island pigs have significant infection with *Trichinella*.

Leptospirosis is a zoonotic disease caused by a bacterium, *Leptospira interrogans*. The bacteria are shed in pig urine, and can be transmitted to other animals at watering holes in which pigs have wallowed. The period of active infection is brief and *Leptospira* is only viable in water for a short time (Jessup and Swift 1993). However, antibodies to *Leptospira* are common (83%) in California pigs.

Pig Management in the State of California

The California Fish and Game Commission in 1956 declared wild pigs a game mammal, and since that time pig range, hunter interest and annual kill have expanded (Barrett 1999). With current wild pig numbers in California estimated at 70-80,000, the species is nearly as important a big game species as deer. However, problems with pig depredation exist statewide, and the state of California must balance its management of the pig as a game animal with the need to control pig damage on public and private lands (Updike and Waithman 1996).

Based upon his observation of pig distribution and abundance on Santa Cruz Island, Sterner (1990) stated it was unlikely that sport hunting could control pig populations, unless the annual take was more than 50% of the pig population. Barrett (1999 pers. comm.) later stated that it was likely that 70% of the population would need to be removed on an annual basis to maintain a low and stable number of pigs on the island.

Pig Eradication Efforts

Feral pigs have been successfully eradicated from areas using a variety of methods, including traps, hunting, and hunting with dogs, and with boundary fencing to limit future incursions of pigs (Barrett et al. 1988; Sterner and Barret 1991). These are the primary tools used in the successful eradication campaign underway on neighboring Santa Catalina Island, as well as the model being used in Hawaii Volcanoes National Park.

Native Vegetation

Introduction

The vegetation communities on Santa Cruz Island, like those of the other Channel Islands, developed in relative isolation from the mainland. Although many species on the islands are the same as those found on the mainland, almost 50 are unique to the Channel Islands. These endemic species can be confined to one or more of the islands. Some of these endemic species are believed to have developed on the islands through adaptive radiation (Sauer, 1988). Other Channel island endemic species are remnants from more widespread populations that once occurred on the mainland. Aside from long-term climatic changes these vegetation communities developed in the absence of major disturbance pressures from the end of the Pleistocene (approximately 12,500 years ago) until European settlement of the island in the mid- 1800's. That is not to say however that disturbance pressures were completely absent from the island during this period. Humans have probably been present on the island since approximately 10,000 – 11,500 years ago. The first human inhabitants were probably Native Americans who reached the islands from the mainland. Archeological evidence indicates that sizable human populations were present on all of the larger Channel Islands by about 7000 B.P. There is little doubt that these first inhabitants altered the vegetation on the islands in some fashion. It is likely that they exerted an impact on island vegetation through food-gathering activities. They may have deliberately set fires to encourage certain plants to grow and for easier access through and to certain areas. They may have also cut down trees or shrubs for

shelter, for fuel, and to make baskets. Because these early inhabitants were mobile and likely moved from island to island, and to and from the mainland, they may have also, inadvertently or deliberately, introduced new plants and animals to the islands.

Even with the impacts associated with early Native American habitation of the islands, it probably wasn't until the arrival of European traders around the mid-eighteenth century that the island vegetation became seriously altered. It was during this era that goats, pigs, rabbits, and sheep were variously released on some or all of the islands. Left alone, these animals became feral and the lack of predators on the islands allowed them to quickly reproduce. As their numbers grew, these alien herbivores severely impacted the native vegetation and probably extirpated many plant species, which had developed for thousands of years isolated from grazing. By the 1830's settlers had moved on the islands to farm and raise livestock. Rabbits were released on some of the islands to be followed by cattle and more sheep. These settlers also brought with them non-native plant species, many of which were adapted to the pressures of grazing and consequently thrived at the expense of the native vegetation in the presence of the introduced herbivores.

Santa Cruz Island Vegetation

Sheep were first introduced to Santa Cruz Island around 1850. Their numbers on the island were allowed to grow fairly unchecked with periodic round-ups to shear and slaughter some of the stock. By 1875 there were an estimated 60,000 sheep on the island, only half of which could be rounded up for shearing annually (Sauer, 1988). During drought years tens of thousands were slaughtered to forestall starvation. Attempts at management of the stock continued until 1939 when the Stanton Ranch, who had acquired 90% of SCI in 1937, began a concerted effort to install fencing and to round up all the sheep. By the 1970's over 263,000 sheep had been captured and sent to market or slaughtered (Warren, ca 1954; Santa Cruz Island Company Records). Due to the severe grazing that had occurred, coastal prickly pear (*Opuntia littoralis*), a native cactus and component of island coastal bluff scrub, began to expand. By 1939 the Stanton Ranch estimated that 40% of the rangeland on the island was useless because of dense *O. littoralis* stands. The ranch then enlisted the help of entomologists from the University of California, Riverside and began releasing biological controls to control the Opuntia. Although several insects were released, the most successful was a cochineal scale insect, *Dactylopius opuntiae*, which since 1951 has destroyed most of the dense *Opuntia* populations on the island (Sauer, 1988).

In 1978, The Nature Conservancy secured permanent protection for the Stanton holdings and began a more intensive program of fencing, trapping, and hunting to remove the remaining feral sheep on the Stanton portion of the island. In early 1987 Nature Conservancy became the sole owner and manager of 90% of Santa Cruz Island. In this same year The Nature Conservancy had completed its sheep eradication program. The Nature Conservancy then ceased what had been the Stanton ranching operation and removed all of the cattle from the island. At this juncture, the remaining herbivores on the island were feral pigs and sheep. The feral sheep were, for the most part, confined to the eastern 10% of Santa Cruz Island. In 1997 the National Park Service fully acquired the eastern 10% of Santa Cruz Island (ESCI). ESCI was incorporated into Channel Islands National Park, which began removing the estimated remaining 9,000 sheep within its boundary. The National Park Service concluded an intensive 3-year effort to remove sheep from Santa Cruz Island. This effort has successfully removed approximately 9,270 sheep from the island. At publishing time of this document it is believed that Santa Cruz Island is sheep-free, however, vigilant monitoring for remaining sheep is on-going.

The severe grazing pressure that has occurred on SCI over the past 150 years has

adversely affected most of the island's plant communities by altering their population structure, the natural size and stature of dominant species, as well as species diversity and composition (Hochberg et al., 1980; Sauer, 1988; Van Vuren and Coblentz, 1987). Grazing of selected plant species has reduced the range of many native species (e.g. *Coreopsis gigantea, Hazardia detonsa*, *Lupinus albifrons*, and *Mimulus flemingii*) and increased the range and abundance of other taxa (e.g. *Eremocarpus setigerus*, *Opuntia littoralis*, *O. oricola*, *Senecio flaccidus*) (Junak et al., 1995). The adverse effects of feral sheep and pigs on Santa Cruz Island have been well documented (Hochberg et al., 1980; Van Vuren and Coblentz, 1987). At the east end of the island, adverse impacts to vegetation were noted by Brumbaugh (1980b) by comparing maps drawn in 1856 with aerial photographs taken in 1929. The vegetation on SCI is to a large degree determined by the island's topographic and geologic factors. The underlying geology of SCI is dominated by Santa Cruz Island Volcanics overlain with eroded Pleistocene terrace deposits. ESCI for the most part rises abruptly out of the ocean and its interface with the ocean is dominated by steep cliffs, covered by coastal bluff scrub. Away from the cliffs the topography flattens out and annual grasslands dominate on these coastal terraces. The coastal terraces are beginning to recover from over a century of grazing. These grasslands are currently a complex of native grasses, annual grasses, and re-colonizing shrubs such as coastal sage and chaparral species. As one moves towards the isthmus, which links ESCI with the main portion of Santa Cruz Island, the topography becomes quite steep and patches of island chaparral, oak woodland, and ironwood groves occur. Originating from these steep slopes are riparian drainages which have cut through the coastal terraces as they outlet to the sea. To the west of these steep slopes lies the isthmus. Here most of the bedrock is composed of sandstones, cherts and diatom-rich shales from the Monterey Formation. This material erodes readily into a reddish, clay-like soil (Schoenherr et al. 1999). Island chaparral and oak woodland are the dominant vegetation communities on the isthmus. The rest of SCI is characterized by a large central valley, which cleaves the main part of the island on a diagonal. The valley is actually a fault, the Santa Cruz Island Fault. The valley is bordered by gentle to steep slopes to the north and south. This topography is overlain with a mosaic of plant communities.

Different authors have variously described the vegetation communities on SCI. Philbrick and Haller (1977) noted eight upland plant communities and two wetland vegetation types. Minnich (1980) in turn reduced the island's vegetation communities into six physiognomic categories by combining some categories and discarding others. In contrast, Holland (1986), expanded the island plant communities into 14 different types: southern foredune, southern dune scrub, southern coastal-bluff scrub, Venturan coastal-sage scrub, valley needlegrass grassland, non-native grassland, island chaparral, island-oak woodland, southern Bishop-pine forest, coastal and valley freshwater marsh, freshwater seep, southern coast-live-oak riparian forest, and mule-fat scrub. For the purposes of this document we will use the vegetation as described in, "A Flora of Santa Cruz Island" (Junak et al. 1995) which is based on the Philbrick and Haller (1977) and Holland (1986) classifications. There are 16 vegetation communities described under that Flora, southern beach and dune, valley and foothill grassland, coastal-bluff scrub, coastal-sage scrub, coyote-brush scrub, island chaparral, island woodland, southern coastal oak woodland, Bishop pine forest, intertidal and subtidal marine community, coastal marsh and estuary, freshwater seeps and springs, vernal ponds, riparian herbaceous vegetation, mule-fat scrub, and southern riparian woodland.

Coastal Bluff Scrub

This vegetation community is confined to the steep cliffs that surround much of Santa Cruz Island and on steep canyon walls and outcrops in

the interior (Junak 1995). Due to the inaccessibility of these bluffs this community has remained largely intact and unaffected by the grazing impacts felt on other parts of the island. This plant community has been called a refugium for some plant species. It is thought that many plant taxa now confined to the coastal bluffs will spread out into other areas of the island now that the sheep have been removed. On the north side of the island, plant taxa which are found in this community include: *Artemisia californica, Astragalus miguelensis, Achillea millefolium, Adiantum jordanii, Antirrhinum nutallianum, Coreopsis gigantea, Dudleya greenei, Eriogonum arborescens, Eriogonum grande var. grande, Erigeron glaucus*, and *Hazardia detonsa* among others. On the south side of the island, common coastal bluff species are similar to those on the north side but also include *Salvia mellifera, Encelia californica,* and *Mimulus longiflorus* as well as other plant taxa. There are also two federally listed plant species, *Arabis hoffmanii* and *Malacothrix indecora*, which are presently confined to coastal bluff scrub.

Grassland

This is a widespread plant community and may be the most dominant vegetation type on SCI. Introduced annual grasses are the most common types of plant species within this community, although extensive patches of native perennial bunchgrasses, which are dominant in some areas, do occur. This community can be found on the coastal terraces and all slopes where heavy grazing has occurred. It is believed that the current extent of the annual grassland community has been created and artificially maintained by historic grazing practices and the feral herbivores on the island. Occasionally, solitary native shrubs such as lemonade berry *(Rhus integrifolia*), manzanita (*Arctostaphylos* sp.), and oaks (*Quercus* spp.), and others are found in the middle of these large annual grasslands indicating that native shrub communities may have previously existed there. With the removal of the feral sheep it is expected that these native shrubs will begin to expand and change what is now annual grassland back to other communities such as coastal sage scrub and island chaparral. The more prevalent exotic annual grasses include: *Bromus diandrus, Bromus hordeaceus, Avena fatua, Avena barbata, Lolium multiflorum, Bromus madritensis*, and *Hordeum murinum*. Native forbs and perennial bunchgrasses also occur within this community and these species include: *Bloomeria crocea, Dichelostemma capitatum, Lasthenia californica, Layia platyglossa, Ranunculus californicus, Sisyrinchium bellum, Nassella pulchra, and Hordeum brachyantherum* ssp. *californicum.* Within this community, native plants such as *B.crocea* and *D. capitatum,* which store energy reserves in underground bulbs, tubers, or corms, are often the hardest hit by the feral island pigs.

Island Chaparral

Island chaparral is found throughout SCI, primarily on the north-facing slopes. Although similar to chaparral found on the mainland, there are some differences both structurally and floristically. Structurally, the dominant island chaparral species are taller and more arborescent resulting in a more open woodland appearance. This may be due in part to climatic differences, a lower fire frequency, or the effects of long-term, intensive grazing. Floristically, island chaparral differs from mainland chaparral in that there is a heavy component of endemic manzanitas and oaks. Within the Central Valley and in Islay Canyon this community is dominated by chamise (*Adenostoma fasciculatum* var. *fasciculatum*), Santa Cruz Island manzanita (*Arctostaphylos insularis*), island ceanothus (*Ceanothus arboreus*), toyon (*Heteromeles arbutifolia*), and mountain mahogany (*Cercocarpus betuloides* var. *blancheae*). On the Monterey Shale bedrock of the isthmus, island chaparral is dominated by a prostrate variety of chamise (*Adenostoma fasciculatum* var. *prostratum*), McMinn's manzanita

(*Arctostaphylos viridissima*), toyon (*Heteromeles arbutifolia*), and island scrub oak (*Quercus pacifica*). Island scrub oak can be the dominant plant species within this community and its dense, shrubby form and the abundant acorn production provides an almost perfect haven for the island feral pigs.

Coastal Sage Scrub

The coastal sage scrub community occurs on dry, rocky slopes throughout Santa Cruz Island. It is most common on the south-facing slopes in the central and eastern portions of the Central Valley (Junak et al 1995). Although much of the coastal sage scrub community has been heavily disturbed, some intact areas do occur on the slopes east of Valley Anchorage. In these "intact" areas, nearly impenetrable thickets of shrubs approximately 3-4 ft. tall are found. Dominant species within this community include: *Artemisia californica*, *Castilleja lanata* ssp. *hololeuca*, *Encelia californica*, *Eriogonum arborescens, Rhus integrifolia, Hazardia squarrosa, Opuntia littoralis*, and *Salvia mellifera*. Non-native annual grasses dominate the heavily disturbed areas of coastal sage scrub with occasional coastal sage scrub species scattered throughout. Coastal sage scrub intergrades with grasslands on gentle slopes with deeper soils and with island chaparral on north-facing slopes.

Southern Beach and Dune

Although steep coastal bluffs surround much of the perimeter of the island, a number of sandy beaches do occur especially on its south side. These sandy beaches for the most part are not large enough to form the typical southern dune scrub communities found on the mainland. Plant species found in these "limited" dune communities include sticky-sand verbena (*Abronia maritima*), silver beach-bur (*Ambrosia chamissonis*, sea rocket (*Cakile maritima*), beach evening-primrose (*Camissonia cheiranthifolia* ssp. *cheiranthifolia*), salt grass (*Distichlis spicata*), California saltbush (*Atriplex californica*), and Australian saltbush (*Atriplex semibaccata*). In the more stable dune areas, native plants such as, prostate coastal goldenbush (*Isocoma menziesii* var. *sedoides),* and silver lupine (*Lupinus albifrons* ssp. *douglasii*), also occur.

Riparian

The riparian vegetation on SCI is different than those found on the mainland. Riparian areas in general are the hardest hit vegetation community under intensive grazing regimes and the island riparian zones have been no exception. In many areas the native riparian plant species have been locally extirpated and non-native plants and grasses occupy the riparian zone. Historically, these areas were probably less diverse than comparable communities on the mainland. Mainland riparian dominants such as, white alder (*Alnus rhombifolia*), sycamore (*Plantanus racemosa*), and California bay (*Umbellularia californica*) do not occur on the islands (Junak et al, 1995).

Where the island riparian vegetation still exists it can be divided into two components: herbaceous riparian vegetation and woodland riparian vegetation. Herbaceous riparian vegetation occurs in canyon bottoms where soil moisture is available for most of the year. The more common plant species in this community include: California maidenhair (*Adiantum jordanii*), *Agrostis viridis*, sticky baccharis (*Baccharis douglasii*), mule fat (*Baccharis salicifolia*), toad rush (*Juncus bufonius*), common monkey flower (*Mimulus guttatus*), and cattail (*Typha domingensis)*.

Island riparian woodland can be found along permanent streams, especially on the north side between Cueva Valdez and Canada del Agua at the western end of the isthmus. Although heavily disturbed, Canada del Agua contains native riparian species such as big-leaf maple (*Acer macrophyllum*), stream orchid (*Epipactus*

gigantea), and California bulrush (*Scirpus californicus*). On the south side of the island, riparian woodlands are found in Alamos Canyon and in the Coches Prietos drainage. Santa Cruz Island riparian zones are dominated by black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), coast live oak (*Quercus agrifolia*), and willow (*Salix* spp.). The understory of this community is comprised of species found in the herbaceous riparian community as well as honeysuckle (*Lonicera hispidula* var. *vacillans*), blackberry (*Rubus ursinus*), and giant chain fern (*Woodwardia fimbriata*) in the wetter drainages.

Bishop pine woodland

Bishop pine, which occurs on Santa Cruz and Santa Rosa islands, is patchily distributed along the coast as far north as Humboldt County and down into Baja California. The phenology of this species can be highly variable and there is some controversy as to whether there is only one species, two species, or one species with two varieties or two forms. Some have proposed two varieties of Bishop pine, a northern variety, *Pinus muricata var. borealis*, and a southern variety, *P. muricata var. muricata*. Others have proposed that there be but two forms, *P. muricata forma muricata* and *P. muricata forma remorata*. Junak (1995) recognizes the two forms of *P. muricata*, *forma muricata* and *forma remorata*. Both these forms are present in the Bishop pine woodland on Santa Cruz Island. Large occurrences of Bishop pine are found on north-facing slopes in the upper reaches of Canada Christy, near Pelican Bay, and south of China Harbor. Smaller occurrences of Bishop pine are found in the upper portion of Canada de los Sauces, on Sierra Blanca ridge, and on the south side near China Harbor. Occasional overstory species mixed within the Bishop pine community includes: island ironwood (*Lyonothamnus floribundus ssp. aspleniifolius)*, coast live oak (*Quercus agrifolia*), and island oak (*Q. tomentella*). Understory species include: chamise (*Adenostoma spp.)*, coyote brush (Baccharis spp.) globe lantern (*Calochortus albus*), toyon, mouse ears (*Hypochaeris glabra*), island deerweed (*Lotus dendroideus var. dendroideus*), island monkeyflower (*Mimulus flemingii*), chaparral current (*Ribes malvaceum var. malvaceum*), poison oak (*Toxicodendron diversilobum*), canyon sunflower (*Venegasia carpesioides*), and the rare island barberry (*Berberis pinnata ssp. insularis*).

Island Woodland

This vegetation community can be found on SCI on deep, moist, rocky soils on the north-facing slopes, ravines, and canyons, particularly at the higher elevations (Cheatham and Haller, 1975, Philbrick and Haller 1977). Many of the dominant trees and shrubs in this community are endemic to one or more of the islands. Over-story species can vary from a mixture of island endemics to stands dominated by oak (*Quercus* spp.) or ironwood (*Lyonothamnus floribundus*). Other dominant species include toyon (*Heteromeles arbutifolia*), and island cherry (*Prunus ilicifolia* ssp. *lyonii*). The oak species found in this community are canyon live oak (*Quercus chrysolepis)*, Macdonald's oak (*Q. macdonaldii*) and island oak (*Q. tomentella*). This community intergrades with island chaparral on dry, rocky slopes, and form savannas on the deeper soils of the flats and more gentle slopes. The current extant of the savannas may be an artifact of the island's grazing history. Understory species include bent grass (*Agrostis pallens*), coyote-brush (*Baccharis pilularis*), Galium spp., manroot (*Marah macrocarpus*), island monkeyflower (*Mimulus flemingii*), lemonade berry (*Rhus integrifolia*), death camas (*Zigadenus fremontii*), and California polypody (*Polypodium californicum*).

Southern Coastal Oak Woodland

The dominant species within this community is coast live oak (*Quercus. agrifolia*)

and it occurs on north-facing slopes and shaded canyons in the Central Valley and on the north side of the island. On the slopes, the more common understory species include toyon, wood mint (*Stachys bullata*), creeping snowberry (*Symphoricarpos mollis*), and poison oak (*Toxicodendron diversilobum*). In the canyon bottoms, common understory species include honeysuckle (*Lonicera hispidula* var. *vacillans*), manroot, blackberry (*Rubus ursinus*), milkmaids (*Cardamine californica* var. *californica*), and climbing penstemon (*Keckiella cordifolia*).

Coastal Marsh and Estuary

Coastal salt marshes are restricted to the upper intertidal zone of protected shallow bays, estuaries, and coastal lagoons (Barbour and Major 1977). Santa Cruz Island has small marshes or wetlands at the estuaries of several canyons including Prisoner's Harbor, Canada de los Sauces, Canada de Malva Real, and Scorpion Canyon. The physical condition of these marshes is dominated by the tides and the duration of tidal flooding. At times, the more shallow estuaries may undergo periodic closure - sometimes seasonal or longer - from the ocean inlets (Barbour and Major 1977). The dominant plant species at each of the marshes on SCI can be quite different but one species that seems to be present at all the sites is *Distichlis spicata* or saltgrass (Junak 1995). Other native species that can be found at one or more of the marshes include *Scirpus californicus, Typha domingensis, Salix lasiolepis, Baccharis douglasii, Baccharis salicifolia, Suaeda taxifolia, and Atriplex californica*. Non-native species also occur at one or more of the marshes or wetlands. These include *Atriplex semibaccata, Cotula coronopifolia, Pennisetum clandestinum, Lythrum hysopifolium, Rumex crispus*, and *Hordeum murinum*. The feral sheep that once inhabited the island extensively used some of these marshes or wetlands. Since the removal of the sheep, vegetative cover, duration of flooding, and the depth of standing water has increased dramatically, especially in the estuaries on the south side of the island (Junak 1995).

Vernal Pools

Several vernal pools or ponds can be found scattered on Santa Cruz Island and more specifically at the western end of the isthmus near China Harbor. It is presumed that these vernal pools once supported an assemblage of native flora but because of the intensive grazing history of the island most of the plant species that occur within these pools are weedy non-natives. Species identified by Junak occurring in the vernal ponds near China Harbor include: Australian saltbush (*Atriplex semibaccata*), bindweed (*Convolvulus arvensis*), short-podded mustard (*Hirschfeldia incana*), common plantain (*Plantago major*), curly dock (*Rumex cripus*), common sow thistle (*Sonchus oleraceus*), and annual exotic grasses.

Mule-fat Scrub

According to Junak (1995), this community appears on level, broad floodplains throughout the island. The seasonally flooded alluvial deposits are dominated by *Baccharis salicifolia* with occasional stands of willow (*Salix lasiolepis, S. exigua*) where the water table is high. Associated species include *Astragalus trichopodus* var. *lonchus*, *Calystegia macrostegia* ssp. *macrostegia*, *Ceanothus arboreus, Ceanothus megacarpus* ssp. *insularis*, *Epilobium canum*, *Eriogonum grande* var. *grande*, *Gnaphalium bicolor, Gnaphalium californicum, Lotus dendroideus* var. *dendroideus*, *Lotus grandiflorus* var. *grandiflorus, Rhamnus pirifolia*, and *Rhus integrifolia*. There is concern that *Tamarix ramosissima* has become established in scattered localities within this community. Tamarisk has proven to be an invasive weed along riparian corridors on the mainland.

Coyote-brush Scrub

This vegetation community is widespread on SCI at elevations below 500 ft. It is found primarily on moderate slopes and flats with loam to sandy clay loam soils (Clark et al, 1990). It intergrades with coastal sage scrub on rocky slopes. As with most of the vegetation communities on SCI, this shrubland has been heavily disturbed by grazing. Many species found in the community are weedy non-native plants, particularly the annual grasses. Typical alien plant species include wild oats (*Avena* spp.), rip-gut brome (*Bromus diandrus*), soft-chess (*Bromus hordeaceus*), and black mustard (*Brassica nigra*). Yellow starthistle (*Centaurea solstitialis*) and fennel (*Foeniculum vulgare*), both destructively invasive non-native plants, are found in coyote-brush scrub.

Fennel Dominated Areas

Approximately 1,800 acres on the north side slopes of the isthmus are dominated by fennel. In some areas, fennel cover approaches 100% with little native vegetation present (personal observation). Other areas within the 1800 acres contain a mixture of fennel, annual grasses, and native vegetation. The most common native species in these areas are coyote brush (*B. pilularis*), California sagebrush (*Artemisia californica*), and island buckwheat (*E. grande var. grande*). Other, less common, native plant species in these areas include yarrow (*Achillea millefolium*), green everlasting (*Gnaphalium californicum*), and island paintbrush (*Castilleja lanata ssp. hololeuca*). Fennel cover in these areas ranges from 30 to 60 percent. Interspersed within these areas are moderate to steep sloping drainages where the native plant community is largely intact and fennel cover is low. There are also areas, covering approximately 1,600 acres, within the Central Valley of the island that are dominated by fennel to varying degrees.

Threatened and Endangered Plant Species

Introduction

There are nine plant species federally listed as Threatened or Endangered on Santa Cruz Island: *Dudleya nesiotica, Malacothrix indecora, Malacothamnus fasciculatus ssp. nesioticus, Helianthemum greenei, Galium buxifolium, Thysanocarpus conchuliferus, Arabis hoffmannii, Malacothrix squalida, and Berberis pinnata var. insularis*. The feral pigs on the island variously threaten each of these. The federal listing proposal for these species identified feral pigs as a major cause of decline for each of the plant species. The primary cause of impact to these rare species by feral pigs are rooting, direct feeding, and soil erosion.

Galium buxifolium

Galium buxifolium, or island bedstraw, is a small, woody shrub with separate male and female plants. Individuals can grow to a height of 4-ft. (1.2 m) with numerous branches. The leaves of this taxon are larger than those of most other species in the genus. This helps to distinguish it from the six other *Galium* species found on the Channel Islands.

Island bedstraw is known to occur on both Santa Cruz and San Miguel Islands. On Santa Cruz Island eight occurrences have been identified. In 1980, of these eight occurrences, two had populations of 50 plants or less and the remaining occurrences had less than six plants each (Hochberg et al 1980b). Two occurrences of *G. buxifolium* were discovered on San Miguel Island in 1993. One occurrence contained approximately 200 plants while the other occurrence contained fewer than 10 individuals. These two occurrences were re-located in 1998 and numbered 300 and 121 plants each. There are historical records of five additional occurrences on the island but no plants have

been located at these sites for approximately 30 years.

Island bedstraw grows on bluffs and rocky slopes in coastal sage scrub and island pine forest. Associated species include California sagebrush (*Artemisia californica*), San Miguel Island locoweed (*Astragalus miguelensis*), giant coreopsis (*Coreopsis gigantea*), Greene's dudleya (*Dudleya greenei*), seaside daisy (*Erigeron glaucus*), and red buckwheat (*Eriogonum grande* ssp. *rubescens*). On the steep, rocky, cliffs other associated species include: yarrow (*Achillea millefolium*), San Miguel Island deerweed (Lotus *dendroideus* var. *veatchii*), cliff aster (*Malacothrix saxatilis* var. *implicata*), wild cucumber (*Marah macrocarpa*), and lemonade berry (*Rhus integrifolia*).

Island bedstraw is threatened by soil loss and herbivory from feral pig rooting, and random (stochastic) extinction events due to its limited population size and range (USFWS 2000). The U.S. Fish and Wildlife Service (USFWS) listed this taxon as Endangered in 1997.

Helianthemum greenei

Helianthemum greenei, or island rush-rose, is a small shrub in the Cistaceae family. It can grow up to 18 inches tall and has alternate leaves covered with star-shaped hairs. It is distinguished from the common rush-rose (*H. scoparium*) by the dense reddish, glandular hairs that grow on the flower stalks. Island rush-rose was originally described by Robinson in 1895 and its type locality was a "dry summit near the central part of the island of Santa Cruz" (Abrams 1951).

Island rush-rose has been reported from four islands: San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina. Both McMinn (1951) and Thorne (1967) reported seeing island rush-rose on San Miguel Island, but no collections from the island exist nor are there any known extant occurrences. On Santa Rosa Island, two collections were made from the 1930's but the plant had not been seen on the island since until April 1999 when two plants were found within a recently constructed elk and deer exclosure. In the spring of 2001, two additional occurrences of *H. greenei* were discovered on the northeast side of Santa Rosa Island. These two occurrences were comprised of one and two individuals (personal observation). Two extant occurrences of island rush-rose are also known from Santa Catalina Island (USFWS 2000).

There are 14 occurrences of island rush-rose on Santa Cruz Island. In 1994 and 1995, surveys sponsored by the Biological Resources Division of the USGS re-located all of those occurrences, ten of which had a mean number of nine plants. The remaining 4 occurrences ranged between 500 – 1,000 individuals with a mean number of 663 (McEachern and Wilken, 1996). It was subsequently determined the number of individuals in the latter occurrences was related to recent fires that had occurred on the island. This observation of increased numbers after fires suggests the species is a "fire follower" and that an integral part of its life history is spent as seed stored in the soil between fire episodes. This past spring, 6 additional occurrences of *H. greenei* were discovered on the NPS side of the island. The largest of these occurrences contained approximately 25 individuals. The second largest contained 9 plants and the rest were composed of 1or 2 plants. Island rush-rose grows in open, exposed areas in chaparral, coastal sage scrub, and island pine forest.

Island rush-rose is vulnerable to soil loss and rooting by feral pigs (USFWS 1999). This species was listed as Threatened by the USFWS in 1997.

Dudleya nesiotica

Dudleya nesiotica, or Santa Cruz Island live-forever, was first collected from the west end of Santa Cruz Island in 1950. It is a succulent perennial in the stonecrop family. This plant has a short, thick, underground stem

that is topped at the soil surface with 8-16 narrow leaves in a basal rosette. From this basal rosette, several flowering stems will arise.

Santa Cruz Island dudleya is only known to occur at Fraser Point on the west end of Santa Cruz Island. Within this general area, the plant occupies approximately 32 acres. From 1994-1996, estimates of the population ranged from 30,000 to 60,000 individuals.

Santa Cruz Island dudleya appears confined to the lower marine terraces in coastal scrub and grasslands. Associated species at the western end of the occurrence include California saltbush (*Atriplex californica*), crystalline iceplant (*Mesembryanthemum crystallinum)*, alkali heath (*Frankenia salina*, goldfields (*Lasthenia californica*), and pickleweed (*Salicornia subterminalis*). The eastern end of the occurrence is associated with Australian saltbush (*Atriplex semibaccata*), soft-chess (*Bromus hordeaceus*), goldfields, purple needlegrass (*Nassella pulchra*), and vulpia (*Vulpia myuros*).

Although Santa Cruz Island dudleya is a perennial, its leaves die back to the ground every year during the dry late summer and fall months. The underground corm takes several years to develop. This species is vulnerable to competition from non-native grasses, soil erosion, herbivory by feral pigs, and disturbance by pig rooting. Due to its limited range, this species is also threatened by random (stochastic) extinction events (USFWS 2000). In 1997, this species was listed as Threatened by the USFWS.

Arabis hoffmannii

Arabis hoffmannii, or Hoffman's rock-cress, was first collected from the coastal bluffs east of Platts Harbor on Santa Cruz Island. Hoffmann's rock-cress, a member of the mustard family, is a slender herb that lives for several years, flowers and then dies. This plant can grow to approximately 2 feet high and has one to several stems. This species was originally reported from three of the northern Channel Islands, Anacapa Island, Santa Cruz Island, and Santa Rosa Island.

Surveys conducted in the early 1990's though failed to re-locate the one reported occurrence on Anacapa Island. The original occurrence on Santa Rosa Island has also apparently disappeared but in 1996 a new location was discovered in middle Lobo Canyon. This new occurrence consisted of eight plants, three of which were flowering. Park personnel observed two plants flowering last year. There are three known extant occurrences for Hoffmann's rock-cress on Santa Cruz Island. The occurrence near Platts Harbor is located on rocky volcanic cliffs. Only a few dozen plants have been directly observed at this location. Another occurrence is found near Centinela Grade. When this occurrence was re-located in 1990, approximately 30 individuals were noted to exist at the site. Since that time, annual monitoring has found fewer than 30 plants and the very steep rocky site has been repeatedly rooted by pigs (Junak pers. comm.).

Ex situ studies (Wilken 1996) have shown that individual plants can reproduce within two years following establishment. Individual rosettes of the species are monocarpic, flowering once before dying; however, some plants have more than one rosette of leaves. Pollinators do not appear to be necessary for seed set and individual plants can produce between 3,000 – 4,000 seeds. However, monitoring at two of the SCI sites indicates that successful establishment of new plants is low. This is thought to be due to a lack of favorable seed germination sites, a high rate of seedling mortality, or a combination of both factors (Wilken 1996).

Arabis hoffmannii was listed as Endangered by the USFWS in 1997. Identified threats to this species include soil erosion, loss of shrub canopy cover, trampling and predation caused by feral pig rooting, and competition with non-native annual plants. This taxon is also threatened by stochastic extinction events because of its extremely limited distribution and population size (USFWS 2000).

Berberis pinnata ssp. insularis

Island barberry was first collected from Santa Cruz Island, west of Centinela Grade, in 1932. It is a perennial shrub with spreading stems that can reach 25 feet high. The leaves are large and are divided into five to nine shiny leaflets. The flowers are yellow and develop in clusters at the branch tips.

Island barberry was originally reported from three of the northern Channel Islands, Anacapa Island, Santa Rosa Island, and Santa Cruz Island. On Santa Cruz Island, there are three known occurrences. One occurrence is found on the north slope of Diablo Peak. In 1994 it consisted of 24 large stems and 75 small stems. These numbers may represent one to several clonal individuals. The second occurrence is near Campo Raton. In 1979, there were estimated to be fewer than 10 individuals but a recent survey was only able to find two plants. Both of these were reported by Wilken to be in danger of being uprooted from erosion (USFWS 2000). The third occurrence, at Hazard's Canyon, was reported by Junak to consist of approximately 20 stems, which may all be clonal (USFWS 2000). Both Santa Rosa Island and Anacapa Island were reported to each have one known occurrence of island barberry. Both of these occurrences are now thought to be extirpated.

Island barberry reproduces both sexually and asexually. Although it appears that pollen from the same plant is able to produce fertile seed, pollination by insects may be necessary to ensure seed set. Research by Wilken showed that each flower can produce two to three seeds but only eight out of 40 seedlings survived long enough to produce secondary leaves (USFWS 1999). Island barberry reproduces asexually by sprouting from underground stems. It is for this reason that the appearance of many stems may represent only one genetic individual.

Identified threats to island barberry include soil erosion and habitat alteration caused by feral pig rooting, lack of successful sexual reproduction, and extinction from random disturbance events (USFWS 2000). This species was listed as Endangered by the USFWS in 1997.

Malacothamnus fasciculatus var. nesioticus

M. fasciculatus var. nesioticus, or Santa Cruz Island bushmallow, was first collected from Santa Cruz Island in 1886 and is endemic to the island. It is a small to medium sized semi-woody shrub in the mallow family. This species can grow up to 6 feet tall, and has slender branches covered with star-shaped hairs. The leaves are bi-colored, dark green on the upper surface and gray on the lower surface. The flowers are pale rose colored and are scattered along the ends of the branches.

Currently there are three known occurrences of Santa Cruz Island bushmallow and all are found within chaparral and the remnant coastal sage communities. The number of individuals found within the three occurrences ranges from 19 to 60 plants. However, like island barberry, this species can reproduce asexually and the number of plants counted represent clones from only 3 – 10 genetic individuals. Cuttings grown at the Santa Barbara Botanic Garden have produced hundreds of flowers but have yielded only two to three seeds per plant. On Santa Cruz Island, associated plant species include Island scrub oak (*Quercus pacifica*), California sagebrush (*Artemisia californica*), Santa Cruz Island buckwheat (*Eriogonum arborescens*), toyon (*Heteromeles arbutifolia*), and lemonade berry (*Rhus integrifolia*).

Threats to Santa Cruz Island bushmallow include soil erosion and habitat alteration from feral pig rooting, and extinction from random disturbance events (USFWS 2000). This species was listed as Endangered by the USFWS in 1997.

Malacothrix indecora

Malacothrix indecora, or Santa Cruz Island malacothrix, is a mat-like herb in the sunflower family. The stems grow up to 4 inches tall and are surrounded by numerous fleshy leaves. The flowers are small and are yellowish-green in color.

Santa Cruz Island malacothrix is known to occur on three islands: San Miguel, Santa Rosa, and Santa Cruz. This species was originally collected from Santa Cruz Island in 1886 by Greene. It occurs on the edge of vegetated habitat along coastal bluffs and is often associated with midden soils. Because it is an annual species, the number of individuals can vary widely within an occurrence from year to year. On Santa Cruz Island, near Black Point, an occurrence discovered in 1980 by Steve Junak was observed to have several hundred plants in 1985. In 1989, however, this same occurrence was found to contain only 50 plants. Historically, there have been two to three occurrences recorded from Santa Cruz Island but these are thought to have been extirpated. Presently only one occurrence is known to exist on Santa Cruz Island, near Black Point.

Identified threats to Santa Cruz Island malacothrix include soil erosion and habitat alteration from feral pig rooting, herbivory by feral pigs, trampling by hikers, seabird nesting activity, and extinction from random disturbance events (USFWS 2000). This species was listed as Endangered by the USFWS in 1997.

Malacothrix squalida

Malacothrix squalida, or island malacothrix, was first collected from Santa Cruz Island by Greene in 1886, near Prisoners Harbor. A second collection was made on Santa Cruz Island in 1968, near Potato Harbor. To date the latter occurrence is the only one known to be extant on Santa Cruz Island. However, the plant was also later discovered growing on Middle Anacapa Island in 1963. Additional surveys observed the plant to be confined to several small colonies on top of coastal bluffs at the east-end of Middle Anacapa Island.

Island malacothrix is a small annual plant in the sunflower family. It grows to a height of approximately 12 inches and has basal leaves that can reach 6 inches in length. The flowers are light yellow and are cluster in small hemispheric heads. Through cultivation studies, it is known that this plant is self-pollinating and self-compatible.

Identified threats to *M. squalida* include soil erosion and habitat alteration from feral pig rooting, seabird nesting, and extinction from random disturbance events (USFWS 2000). This plant was listed as Endangered by the USFWS in 1997.

Thysanocarpus conchuliferus

Thysanocarpus conchuliferus, or Santa Cruz Island fringepod, was first collected from Santa Cruz Island in 1886 by Greene and Brandegee. A search of herbarium records identified 14 occurrences on the island. Surveys in 1980 were able to only re-locate 8 of those historical locations. Today the only current extant population is at Portozuela, consisting of only a few individuals. This species is endemic to Santa Cruz Island.

Santa Cruz Island fringepod is a small annual in the mustard family, growing to a height of only 5 inches. There are one to several stems per plant which terminate in a cluster of small pink to lavender flowers. Little is known about this species other than it blooms from March through April and that only one seed is produced per flower.

Identified threats to Santa Cruz Island fringepod are predation, soil erosion, and habitat alteration from feral pig rooting. This species is also threatened with extinction from random disturbance events. In 1997, this plant was listed as Endangered by the USFWS.

Non-Native Vegetation

Introduction

The oldest evidence of human occupation on Santa Cruz Island is 8,900 BP, though evidence from Santa Rosa and San Miguel Islands indicate human presence there are early as 10,000 years BP. The interactions of indigenous peoples with island vegetation included harvesting, habitat disturbance and directed, as well as accidental plant dispersal. They likely made large modifications to the landscape that influenced today's vegetation patterns, by burning, clearing, and cultivation.

The last 150 years have seen an enormous change in the vegetation of the island, in a very short period of time. The most significant factors have been the introduction and proliferation of feral sheep and pigs, cattle grazing, removal of native vegetation cover by these animals, and by the associated ranching and farming activities, and the arrival and spread of aggressive non-native plants.

Extremely high erosion rates have been documented, especially between 1874 and 1920, associated with the introduction of large, non-native grazing animals, particularly sheep. As evidenced by pollen records constructed for nearby Santa Rosa Islands (Cole, 1994), alien plants were arriving and spreading rapidly; presumably they were spreading similarly on Santa Cruz Island, which underwent the same agriculture-related impacts.

Feral pigs have also adversely affected plant communities, especially by trampling and rooting under oak woodland and chaparral canopies. Pig activities have inhibited regeneration of native trees and shrubs, caused destruction of litter and promoted accelerated erosion. The soil disturbance they cause, and the seeds they transport, have facilitated establishment of non-native plants within these communities.

Vulnerability of Islands

Islands and remote peninsulas seem consistently vulnerable to invasion by non-native plants. This may be because they have relatively low numbers of native species, or are missing certain distinctive plant groups, leaving "empty niches" that new arrivals can exploit. It may also be due to having no large native herbivores, so that native plants did not evolve the classic defense mechanisms such as spines, small hard leaves, or foul-tasting chemicals that would have made them unpalatable to the pigs, cattle, sheep and other grazers brought by humans. (Randall 1996)

Current situation on Santa Cruz Island

Santa Cruz Island today has a total of 650 plant taxa; at least 170 of these are introduced. This constitutes about 26% of island's total flora. This figure is at about the median point of the ranges of the proportion of non-native/total flora--20% to 47%--of all the eight California Channel Islands, is slightly lower than the average rate for the northern islands, and is notably lower than the average for the southern islands. Eleven of Santa Cruz Island's 88 plant families and 82 of its 348 plant genera are represented exclusively by non-native taxa.

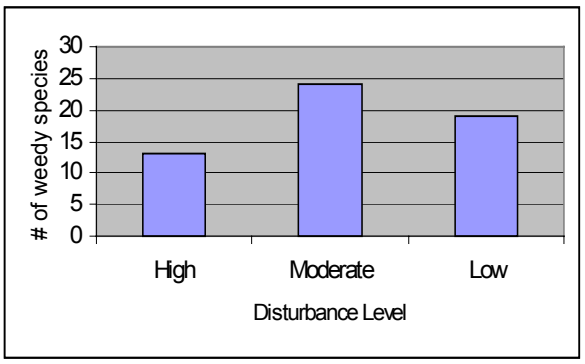
Santa Cruz Island is subject to the continual risk of colonization and re-colonization by non-native plants, because of transport of materials and vehicles to the island, travel to the island by residents and visitors, and natural processes of transport of seeds of non-native plants from the mainland to the islands. Non-native plants tend to be able to capitalize on disturbance to native vegetation, such as fire or grazing animals, to gain a foothold in a new area. Santa Cruz Island is particularly vulnerable to this because of the lack of adaptation by native plants to herbivory.

In general, worldwide, it has been observed that many decades often pass between the first introduction of a plant and its apparently sudden rapid spread. It is presumed that during this

period, seedbanks are developing, seeds are being dispersed, and the species is adapting to local conditions. Many of the species of non-native plants that occur on Santa Cruz Island, as well as on the California mainland, appear to be approaching the end of this 'lag phase', as evidenced by increasing abundance, ranges, and types of habitats invaded, and in the rate of increase of these attributes. Notable among these plants are smilo grass (*Piptatherum milliaceum)*, fennel (*Foeniculum vulgare)*, and tree tobacco (*Nicotiana glauca)*. We expect that many of the island's alien species are poised for this rapid expansion phase, making it even more critical to limit the disturbances that facilitate weed spread.

Alien plants of Santa Cruz Island, like any land management area, can be organized into functional groups, related by elements of their life histories such as physical stature, structure, seed longevity, dispersal mechanisms, type and amount of storage tissues, their relationships to current and previous land uses and past and ongoing disturbances. Distributions and abundance of at least 56 of the approximately 170 alien plants occurring on SCI are particularly dependent on the disturbance caused by the island's feral pigs (Figure 4). Some of the factors affecting this relationship are life history of the species, plants individual size and structure, the species' population patterns and persistence, seed longevity and dormancy mechanisms, and seedbank capability.

Figure 4. Weed species correlated to disturbance level



Fennel

History

Sweet fennel (*Foeniculum vulgare* Mill.) was present in California for over 100 years before it became an aggressive invader (Greene 1887, Jepson 1925, Hickman 1993). Within the last ten years fennel has successfully invaded grassland and coastal sage communities throughout California, displacing the native flora and reducing biodiversity by producing thick monospecific stands (Beatty 1991, Beatty and Licari 1992). In 1996 *Foeniculum vulgare* was placed on the CALEPPC (California Exotic Plant Pest Council) list of California's exotic plant species of greatest ecological concern (Anderson et al. 1996).

Fennel was introduced on Santa Cruz Island in the late 1800's (Greene 1887). Vectors for fennel dispersal during 19th and most of the 20th centuries were likely in the hoofs, fur and feces of cattle (*Bos taurus*) and feral sheep (*Ovis aries*), and along roadside passages (Beatty and Licari 1992, Brenton and Klinger *in press*). Although the grazers dispersed fennel, they also controlled fennel by consuming the plants that germinated and grew in the grasslands and disturbed communities (Brenton and Klinger 1994).

The removal of cattle and feral sheep from The Nature Conservancy portion of the island in the 1980's left Santa Cruz Island with a highly disturbed and vegetation free landscape- the perfect landscape for fennel invasion. Fennel was able to take advantage of this open disturbed space. With the end of a 4-year drought following the removal of grazers, prolific fennel growth occurred across Santa Cruz Island. Fennel spread throughout the Central Valley and into the upper grasslands and coastal sage communities displacing native species (Crooks and Soulé 1999). Fennel's ability to grow and reproduce during the hot and dry Mediterranean summers also increased the spread of fennel (Brenton and Klinger 1994). Fennel spread in many of the previous pasture

areas, and has spread via roadways and feral pigs throughout Santa Cruz Island, producing monoculture thickets with over 90% fennel cover (Klinger 1998, Erskine unpublished data). Currently, a large scale, model fennel management program is underway in Santa Cruz Island's Central Valley. The fennel management proposal for the isthmus of Santa Cruz Island follows the Central Valley management protocol.

Biology

Fennel is a perennial herb that can grow 1-3m tall. It is a dicot species in the Apiaceae family (carrot or parsley family). Economic Apiaceae plants include, among others, dill (*Anethum spp.*), celery (*Apium spp.*), and English-ivy (*Hedera spp.*). Other weedy species in the Apiaceae family, originally introduced as cultivated species include wild caraway (*Carum carvi*), and wild carrot (*Daucus carota*). Two well-known toxic weeds in Family Apiaceae are western water hemlock (*Cicuta douglasii*) and poison hemlock (*Conium maculatum*) (Whitson et. al. 1996, Zomlefer 1994).

Fennel produces a taproot that can range from 0.9-3m in length. It is native to southern Europe, escaped from cultivation in California, and is now a widespread weed. The photosynthetic stems are erect and branched with multiple stems produced from a single crown. The stems are pithy and become hollow as the season progresses.

Fennel reproduces sexually and is a primarily outcrossing species. Pollination occurs predominately via insects. Flower production begins as early as late May and continues through October (Erskine personal observation). Wind is not considered an important pollination device. Flowers are strongly protandrous, and bloom initially in the primary umbels, followed by secondary, then tertiary umbels (Koul *et. al.* 1993). Umbels are large and conspicuous to facilitate insect attraction. Sepals are absent and petals are yellow. Common pollinators of fennel include flies, bees, wasps and beetles. Tens of thousands of seeds can be produced on an individual fennel plant. The two seeds produced per ovary often fall together as one schizocarp (Munz 1986, Zomlefer 1994). Seed dispersal occurs when schizocarps fall off maternal plants to the ground, via water in riparian communities, via animals, anthropogenically (vehicles, shoes, and machinery), and animal dispersal. Some seeds can remain within the umbel over winter, and these seeds are viable the next spring.

Anecdotal evidence suggests a long-lasting seedbank (at least 5-7 years of viability) for fennel, yet there is no quantitative evidence of such a seedbank. Seeds do not require a chilling period or any type of scarification to germinate, although they do appear to need light for germination and growth. Optimal germination temperature ranges between 20ºC and 23ºC and germination primarily occurs within 5-7 days at these temperatures (Erskine unpublished data). With this fast germination time, fennel is able to germinate in early spring and throughout the spring (if rains continue) on Santa Cruz Island. Germination rate after one year of cold storage ranged from 60-85%, at temperatures between 16ºC and 25ºC. (A large portion of the seeds that did not germinate in this study were killed by fungi (Erskine unpublished data)). If the cold storage results are applicable to the field, these results indicate that those seeds that do not germinate the first year from the seedbank have a high probability of germinating the second year, even if the mother plants are removed. For this reason, a single year of treatment would never eradicate fennel.

Fennel possesses many phenotypic traits characteristic of weedy species: rapid growth rate, large seed rain, no specialized germination requirements and short juvenile period (Baker 1965, Erskine personal observation). Fennel also has the ability to reproduce asexually from the crown of the root system.

Fennel possesses biological characteristics that make it a good invader in California, and particularly on Santa Cruz Island. Fennel produces a large taproot to obtain water during

the dry Mediterranean summers, when most other herbaceous species have already set seed and died, and many perennials are dormant. By late June, flower production is in progress, and leaves begin to fall off the stems. Photosynthesis continues through the green, stomatic stems. Erect stems receive less direct light and transpire less than leaves, and therefore decrease summer stress such as high temperatures and water loss, to the plants.

Fennel is known to invade grasslands, coastal sage scrub, savannas, riparian communities, roadsides and most other disturbed communities, all of which are found on Santa Cruz Island. Fennel has the ability to tolerate soil pH values ranging from 4.8-8.3, precipitation between 30cm and 260cm annually, and temperatures between 0ºC and 27ºC (Simon 1984, Erskine personal observation). Fennel proliferates on well-drained loamy soils (Colvin and Gliessman 2000), but can also invade extremely eroded soils, cliff edges and south-facing slopes (Erskine personal observation). The ability to invade a wide variety of communities, and to tolerate extreme heat, dry, and freezing conditions, has allowed fennel to invade many plant communities on Santa Cruz Island. The only communities fennel has not invaded on Santa Cruz Island are those communities with heavy cover.

Fennel appears to need full sunlight to grow, and the seeds cannot germinate in communities with thick canopies. Although fennel seedlings can be found below fennel plants and within Mediterranean annual grass communities, these communities are usually patchy and allow enough sunlight for germination. Fennel seedlings are not generally found in such closed canopy communities as chaparral, oak woodlands and pine stands in the absence of large-scale disturbance (i.e. pig rooting or burning).

Disturbance and Fennel

Fire removes above-ground plant biomass producing open space and canopy gaps that allow for fennel seeds to germinate. Fire alone appears to promote fennel proliferation, but there are no quantifying data to suggest a mechanism for this improved invasion ability other than the increase in sunlight and soil temperatures, conditions that promote fennel seeds germination. In areas of high pig density, and large areas where pigs root, fennel seedlings can be found, as well as newly established adult fennel plants. As with fire, the anthropogenic and pig caused disturbances allow fennel seeds to receive more light, and therefore to germinate and thrive. Feral pigs, vehicles, humans, and machinery are vectors for fennel invasion through the disturbances they cause, and the transport of seeds.

Fennel covers approximately 10% of Santa Cruz Island (Klinger unpublished data), and is currently spreading along roadsides into many coastal sage, grassland and bare/disturbed sites. Although there appears to be distinctly separate large stands of fennel across the island, roads and pig trails are obvious corridors of invasion connecting these fennel populations.

Eradicating feral pigs from Santa Cruz Island would remove this major vector for dispersal and establishment of fennel, this, in turn, would facilitate fennel control throughout the island.

Cultural Resources

Historical Overview

Largest of the Channel Islands and containing a varied and complex series of plant communities, Santa Cruz Island seems to have supported a large human population during most of prehistory. Eleven historic villages are

known for Santa Cruz Island, equal to the total number recognized for both Santa Rosa and San Miguel Islands. Earlier sites, ranging in size from only a few meters square to extensive shell mounds covering hundreds of square meters are found along the coastline and within the interior at advantageous locations. Some of these mounds contain distinctive layers of red abalone shell, indicative of occupation about 5000 to 8000 years ago. In addition to shell mounds, prehistoric sites include chert quarries and workshop sites, rock shelters, and rock pavements ethnographically identified as shrines. Some of the rock shelters contain rock art of a simple style quite distinct from that known on the mainland. Formal cemeteries are found close to many villages, especially later sites, and isolated, seemingly random, human burials are recorded for the island as well. The potential number of burials ranges into the tens of thousands.

This rich complex of sites constitutes the remains of more than 8,000 years of occupation, development, and flowering of the group known as the Chumash, the inhabitants of the northern Channel Islands and the Southern California area from San Luis Obispo to Malibu. Recent research shows occupation 8,900 years ago, and the potential for even older material exists on the island. Like Santa Rosa and San Miguel Islands, deposits on the west end containing pygmy mammoth remains could also contain evidence of older human occupation.

Although Chumash occupation of Santa Cruz Island ended in the early nineteenth century, many individuals who trace their ancestry to specific villages retain a lively interest in the preservation and management of their heritage. Between three and ten thousand Chumash live in California today.

The European presence in the Channel Islands began with Juan Rodriguez Cabrillo's explorations in 1542, followed by the subsequent expeditions of Sebastian Vizcaino in 1602 and George Vancouver in 1769. While sea otter hunters, smugglers, and others visited the islands and left their traces during the historic period, permanent European settlement did not occur on the islands until the mid-1800s.

The Chumash population left Santa Cruz Island by the 1830s, settling primarily in and around the Spanish Missions in Santa Barbara and San Buenaventura. In 1839, the Mexican government granted title to the island to Andres Castillero, who became the first private owner of Santa Cruz Island. In 1853, Dr. James Barron Shaw, acting as agent for Castillero and the island's subsequent owners, the Barron and Forbes Company, began stocking the island with sheep, horses, cattle and hogs. Shaw managed the island rancho until 1869, developing several ranch outposts and the infrastructure that linked them. In 1869, ten San Francisco investors purchased the island and formed the Santa Cruz Island Company. Justinian Caire, a Frenchman and one of the ten investors, acquired the majority of the shares in the Santa Cruz Island Company during an economic downturn in the 1870s and became sole owner of the island by the end of the 1880s or early 1890s. Caire and his descendants continued and expanded the sheep ranching and agricultural enterprises on the island.

The heart of Shaw's and, later, Caire's operation was located in the island's central valley. The main ranch included a residence, bunkhouses for winemakers, shepherds and vaqueros, barns, winery buildings, a dining hall, bakery, laundry, kitchen, shops for wagon makers, blacksmiths and tool and saddle makers, and a chapel. Substantial acreage was planted in grapevines, hay and fruit trees.

Caire's island workforce consisted primarily of French, Italian, Hispanic and Native American workers, reflecting Caire's French origins, his wife's Italian heritage, and the local population. The island operation was a largely self-sustaining community that supported a diversity of permanent and seasonal employees, which included a blacksmith, carpenters, painters, team drivers, dairymen, cooks, stone cutters and masons, gardeners, dairymen, vintners, grape pickers, sheep shearers, wagon

and saddle makers, a cobbler, a butcher, a baker, and a sea captain and sailors.

The island ranching system developed by Shaw included the main ranch and satellite ranches at the east and west ends of the island and at La Playa (Prisoners Harbor). Caire continued to use these ranches, and established additional ranches and camps at other locations on the island. The main ranch and the outranches at Scorpion, Prisoners and Christy remained the primary ranches through the Justinian Caire period. The island's sheep population reached 40,000-50,000 head under Caire, their wool and meat being shipped to market from Scorpion Ranch and Prisoners Harbor. When Caire died in 1897, an unequal distribution of his estate among his heirs led to a prolonged period of litigation. Ultimately, the dispute was settled by a court-ordered partition of the island in 1925, which divided the island into parcels, with the western 90 percent (54,500 acres) of the island going to Caire's widow and four of their children, and the eastern 10 percent (6,000 acres) going to the two married Caire daughters. The Caire family maintained the western portion of the island until 1937, when they sold their land to Los Angeles businessman Edwin L. Stanton. Stanton attempted unsuccessfully to revive the island's sheep business, which had declined dramatically after Justinian Caire's death, and then switched to cattle ranching. Edwin Stanton's son and heir, Carey Stanton, continued the cattle ranching operations after his father's death in 1963. In 1978, the Nature Conservancy secured permanent protection of the property from Stanton, and full control of the property upon Stanton's death, which was in 1987.

The east end of the island remained in the hands of the Caire descendants, consolidated under the ownership of Ambrose and Maria Gherini. They continued the sheep ranching operation, with headquarters at Scorpion Ranch and Smuggler's Cove, the two east end satellite ranches. The ranch operations were overseen by a series of superintendents and caretakers until the island was converted to a private hunting, camping and recreational venture in the early 1980s. The National Park Service acquired full ownership of the east-end of the island in 1997.

Cultural Resources

Santa Cruz Island contains thousands of relatively intact archeological sites filled with rich research opportunities, especially for investigations into human adaptation and development in a context of changing environments and cultural conditions.

More than 630 archeological sites have been recorded on Santa Cruz Island, with intensive survey having covered only perhaps 20% of the island. The entire island probably contains about 3000 archeological sites.

Sites on Santa Cruz Island are receiving increasing attention from archeologists because of the relatively long and undisturbed record remaining on the island. Santa Cruz Island archeological sites remain relatively undisturbed because of the lack of intensive development and the absence of burrowing animals, such as gophers and squirrels, on the island. In contrast to the mainland, where development and burrowing have seriously impacted archeologists' ability to understand the Chumash past, the sites on the island and their relatively natural context constitute the best materials for understanding the past of the Chumash. Feral pigs and their destructive rooting threaten to destroy the record of this rich past.

The island's archeological resources were listed on the National Register in 1978 as the Santa Cruz Island Archeological District. The district encompasses only the western 90 percent of the island because of the division of ownership at the time of nomination and listing. The previous owners of East Santa Cruz Island did not choose to include their holdings within the District. There is no question that the archeology of the eastern portion of the island is at least as significant as the present archeological district, particularly since it contains most of the chert quarries exploited in

the past. The National Park Service is managing the archeological resources on the east end of the island as a property eligible for the National Register until such time as the existing nomination can be amended to add the east end acreage and resources.

In addition to the Chumash record, there is extensive historic archeology centered on the island locations where ranches developed, as well as on the numerous coastal fishing and recreational camps, which flourished around the turn of the 20th century. There are remnants of oil exploration on the island, at least one abandoned World War II military encampment, and the remains of shipwrecks can be found on the beaches and intertidal zone and in the waters surrounding the island.

The ranching and agricultural resources form a historic period cultural landscape over much of the island. The main ranch in the Central Valley is the largest and most significant of the ranch complexes. Most of the earliest buildings constructed under Shaw's superintendence were of adobe or wood, and most have disappeared. During the Caire era, much of the permanent construction was of stone masonry or brick. The design of the buildings with their whitewashed stucco surfaces, large corner quoins and cobble walkways exhibit the Mediterranean heritage of their owners. All of the construction materials except lumber were gleaned from the island; brick was produced in on-island kilns. Corrals and fencelines define the ranching-era work areas, fields and pastures. Furrow lines from the grapevine plantings can still be seen on many of the slopes that were cultivated for wine production.

In addition to the main ranch, significant building complexes remain at Prisoners' Harbor, Scorpion Ranch, Smuggler's Cove and Christy Ranch. Although all of these ranches except Smuggler's Cove were established during Shaw's management of the island, most of the remaining buildings date to the Caire period. The design and construction of the primary buildings on the outranches are similar to that of the main ranch, though they contain fewer buildings and landscape features.

Ranches and outposts once stood at Rancho Punta West, Rancho Nuevo, Buena Vista, Portezuela and Rancho Sur. Their locations are marked now by foundations, plantings and remnants of structures. Stone foundations of barns are found in a number of locations on the east end. A Stanton-period ranch was built at Del Norte in 1952-53. Its frame house and corrals have been maintained by the Santa Cruz Island Foundation.

Most of the island's road system dates to the Caire development period, although the Ridge Road or "Camino Viejo" predated Caire. The central valley roads lined with eucalyptus trees form grand avenues near the main ranch. The Scorpion Valley road supported by an immense dry stone retaining wall illustrates the challenges that the nineteenth-century ranchers faced in developing this difficult terrain. The Stanton family developed many dirt ranch roads in the 1940s through 1960s, especially on the isthmus, and the Navy improved the road from Prisoners' Harbor to the Navy base in 1950.

Dry stone structures, built in the late 1800s by Italian masons and laborers, are found throughout the island. Structures include stone-lined wells, rock retaining walls along stream channels and roads, and more than 200 check dams on the east end alone, built to control water flow and slow erosion. Large rock piles dot the east end of the island, these were created when the fields were cleared for cultivation.

Plantings of eucalyptus, Monterey cypress, pepper tree and other ornamental species are found at the ranch sites and elsewhere on the island, dating primarily to the Caire era. A large olive grove survives at Smuggler's Cove. Orchards and plantings of fruit and nut species are located at the main ranch and many of the outranches. A few rare examples of grape plantings remain in the Central Valley.

Fencelines throughout the island delineate pastures. Remnants of the sheep ranching operations include corrals, watering troughs and

other features. While the nineteenth-century fencelines and features on the eastern end of the island remain relatively unchanged since their construction, the ones on the western part of the island were altered about 50 years ago to accommodate Stanton's cattle operations.

The ranch complexes and cultural landscape features are considered significant under several National Register criteria although they have not yet been evaluated or nominated to the National Register of Historic Places. The long period of ranching and agricultural development has resulted in a pastoral landscape that reflects the island's management by Shaw, Caire and Stanton and which retains a great deal of historic integrity. The island itself may be considered a significant rural historic landscape, or palimpsest of historic landscapes.

Ethnographic Resources

Ethnography is concerned with the peoples associated with parks, with their cultural systems or ways of life, and with the related technology, sites, structures, other material features, and natural resources. Certain contemporary Native American and other communities are permitted by law, regulation, or policy to pursue customary religious, subsistence, and other cultural uses of park resources with which they are traditionally associated. Such continuing use is often essential to the survival of family, community, or regional cultural systems, including patterns of belief and economic and religious life.

Ethnographic resources are locales and sites, structures, objects and rural and urban landscapes assigned cultural significance by traditional users. Traditional users may assign significance to places closely linked with their own sense of purpose, existence as a community and development as ethnically distinctive peoples. To be considered traditional, associations with park resources will usually have endured at least two generations.

Channel Islands National Park has completed a study tracing the lineal descendants Chumash peoples who inhabited the northern Channel Islands, and has identified living descendents of the Santa Cruz Island Chumash. The park has not undertaken a formal ethnographic study to identify other groups with traditional ties to the island. However, the former island owners, including the Caire and Gherini families, whose forebears developed the island beginning in the 1870s, regularly visit the island and work closely with the park and The Nature Conservancy. Members of the Gherini family retain the right of use and occupancy of parcels on East Santa Cruz Island until 2012.

Anthropological sources and members of the local Chumash community clearly identify the Channel Islands as significant to the Chumash culture as their ancestral homeland. The park has facilitated the reburial of exposed human remains on the islands by members of the Chumash community, in accordance with the Native American Graves Protection and Repatriation Act (NAGPRA). The island itself, as well as the archeological sites and burials associated with Chumash occupation of the island, can thus be considered ethnographic resources. Other sites, locales and/or landscapes significant to island descendants and the local Chumash community have not been identified, but may exist.

In the 1970s the Chumash Maritime Association sponsored an inter-island *tomol* (traditional plank canoe) crossing and in 2001 a channel crossing from the mainland to Santa Cruz Island. Attendant celebrations marked these events, with the 2001 event attracting about 200 Chumash to the island. The park has not received any other requests for permits to hold ceremonies on the island or to collect traditional natural resources during the park's management of the island, nor is the park aware of any informal use of Santa Cruz Island for ceremonial or spiritual purposes.

Descendants of the Caire and Gherini families visit the island on a somewhat frequent basis. Gherini family members visit the east end

of the island, where they have use and occupancy rights, approximately 10 times per year, staying at the Scorpion ranch and visiting Smugglers ranch. Caire descendants visit the Main Ranch on The Nature Conservancy property perhaps 2-3 times per year for brief stays. The historic ranch complexes, ranch equipment and ranch landscapes are valued by these families and by many who worked for them on the island as part of their family heritage.

Human Uses and Values

Socioeconomic

Although all of Santa Cruz Island is within the boundaries of Channel Islands National Park, The Nature Conservancy owns the bulk of Santa Cruz Island. The National Park Service currently owns the eastern 24% of the island, while TNC owns the remaining 76%. In August of 2000 TNC completed a gift of 8,500 acres of property to NPS, increasing NPS holdings from 10% to 24%. The conveyance includes lands on the isthmus of Santa Cruz Island. The gift will allow NPS and visitors better access to SCI via Prisoners Harbor, and is intended to facilitate cooperation between NPS and TNC.

Use of the island is very different on lands owned by NPS and lands owned by TNC. In general, Santa Cruz Island lands owned by NPS are fully open to visitor access and use, whereas on TNC public access is limited. TNC does allow private boaters to secure landing permits. Permit holders can land in any anchorage and day hike to anywhere but the Main Ranch. However, they are not permitted to camp on TNC land. TNC licenses Island Packers to conduct public education trips to a variety of locations on the island.

Eastern Santa Cruz Island has been fully open to visitor use since 1997, and has become the most popular visitor destination in the park. The number of visitors to East Santa Cruz Island has increased since the Park completed acquisition of the east end in 1997. The Island Packers Company, as concessionaire, provides boat transportation to Santa Cruz Island, landing visitors at Scorpion Bay on a nearly daily basis. It also provides scheduled trips to several parts of TNC's lands. A campground has been established in Scorpion Valley and is very popular, with use heaviest on weekends and filled to capacity on holiday weekends. Visitor activities on east Santa Cruz include hiking, beach-going, kayaking, and snorkeling. Private boaters also visit east Santa Cruz Island. A popular hike is across east Santa Cruz from Scorpion Valley to Smuggler's Harbor and return.

The conveyance of lands on the isthmus to NPS would bring about changes in land use on that portion (8,500 acres) of the island. Prisoners' Harbor would become the main access point for visitors to the isthmus. The dock at Prisoners Harbor is currently being reconstructed. The NPS will reopen the dock in summer of 2002. Visitor services on the isthmus would be limited at first. Full development of visitor services would not be implemented until a planning effort is completed. Until that time, visitor services would likely be limited to restroom facilities at Prisoners Harbor, and two small backcountry campgrounds near Del Norte, and near Chinese Harbor. The latter facility would allow backpackers to hike from Prisoners Harbor across High Mount to Scorpion Valley.

The other visitor activity currently available for visitors to the isthmus is a reservations-only hike to Pelican Bay. TNC currently allows Island Packers Company to lead visitors on organized hikes to Pelican Bay and return. The Bay is accessible only via TNC-owned lands, and would remain so now that the land conveyance is complete. Additionally, TNC operates a landing permit program that allows private boaters to land at any of the anchorages and day hike in the vicinity.

Scientific research and teaching are the primary uses of TNC lands on Santa Cruz Island. The University of California has operated a field station on Santa Cruz Island since 1966. Santa Cruz Island Reserve is part of the University of California Natural Reserve System. Many researchers carry out projects on Santa Cruz Island through the UC Reserve annually.

Table 7. Number of Visitors on East Santa Cruz Island, 1996-1999.

	1996	1997	1998	1999
Recreational Day visitors on boats	19,870	63,851	50,020	55,818
Recreational Visitors ashore	8,423	13,581	16,395	18,236
Recreational Overnight visitors on boats	8,006	13,471	14,543	12,971
Campers	1,990	5,675	7,413	15,442
TOTAL	**40,285**	**98,575**	**90,369**	**102,467**